

tion. PPV and IPV are recommended by the manufacturer to be administered by the subcutaneous or intramuscular route. Response to vaccines recommended by the subcutaneous route probably will not be affected if the vaccines are administered by the intramuscular rather than subcutaneous route. Repeating doses of vaccine administered by the intramuscular route rather than by the subcutaneous route is not necessary.

Administering volumes smaller than that recommended (e.g., split doses) can result in inadequate protection. Using larger than recommended dosages can be hazardous because of excessive local or systemic concentrations of antigens or other vaccine constituents. Using reduced doses administered at multiple immunization visits that equal a full dose or using smaller divided doses are not endorsed or recommended. Any vaccination using less than the standard dose should not be counted, and the person should be revaccinated according to age, unless serologic testing indicates that an adequate response has been achieved.

## Preventing Adverse Reactions

Vaccines are intended to produce active immunity to specific antigens. An adverse reaction is an untoward effect that occurs after a vaccination that is extraneous to the vaccine's primary purpose of producing immunity. Vaccine adverse reactions are classified by three general categories: local, systemic, and allergic (91). Local reactions are usually the least severe and most frequent. Systemic reactions (e.g., fever) occur less frequently than local reactions. Serious allergic reactions (e.g., anaphylaxis) are the most severe and least frequent. Severe adverse reactions are rare.

Persons who administer vaccines should screen their patients for contraindications and precautions to the vaccine before each dose of vaccine is administered (Table 5). Screening can be facilitated by consistent use of screening questionnaires, which are available from certain state vaccination programs and other sources (e.g., the Immunization Action Coalition at <http://www.immunize.org>).

Syncope (vasovagal or vasodepressor reaction) can occur after vaccination, most commonly among adolescents and young adults. During 1990–2004, a total of 3,168 reports to Vaccine Adverse Event Reporting System (VAERS) were coded as syncope; 35% of these episodes were reported among persons aged 10–18 years (CDC, unpublished data, 2005). Approximately 14% of reported syncopal episodes resulted in hospitalization because of injury or medical evaluation. Serious injury, including skull fracture and cerebral hemorrhage, has resulted from syncopal episodes after vaccination (92). A review of syncope after vaccination indicated that 63% of syncopal episodes occurred  $\leq 5$  minutes after vaccination, and

89% occurred within 15 minutes after vaccination (93). Although syncopal episodes are uncommon and severe allergic reactions are rare, vaccine providers should strongly consider observing patients for 15 minutes after they are vaccinated (94). If syncope develops, patients should be observed until the symptoms resolve.

## Managing Acute Vaccine Reactions

Although rare after vaccination, the immediate onset and life-threatening nature of an anaphylactic reaction require that all personnel and facilities providing vaccinations have procedures in place for managing a reaction. All vaccine providers should be familiar with the office emergency plan and be certified in cardiopulmonary resuscitation. Epinephrine and equipment for maintaining an airway should be available for immediate use.

Anaphylaxis usually begins within minutes of vaccine administration (95,96). Rapidly recognizing and initiating treatment are required to prevent possible progression to cardiovascular collapse. If flushing, facial edema, urticaria, itching, swelling of the mouth or throat, wheezing, difficulty breathing, or other signs of anaphylaxis occur, the patient should be placed in a recumbent position with the legs elevated. Treatment options for management of anaphylaxis using pharmaceuticals have been recommended (Table 8) (94,97). Maintenance of an airway and oxygen administration might be necessary. Arrangements should be made for immediate transfer to an emergency facility for further evaluation and treatment.

## Occupational Safety Regulations

Bloodborne diseases (e.g., hepatitis B, hepatitis C, and human immunodeficiency virus [HIV]) are occupational hazards for physicians and other health-care providers. To reduce the incidence of needle-stick injury and the consequent risk for bloodborne diseases acquired from patients, the Needlestick Safety and Prevention Act was enacted in November 2000. The Act directed OSHA to strengthen its existing bloodborne pathogen standards. Those standards were revised and became effective in April 2001 (69). These federal regulations require that safer injection devices (e.g., needle-shielding syringes or needle-free injectors) be used for injectable vaccination in all clinical settings. The rules also require that records be kept documenting injuries caused by medical sharps and that nonmanagerial employees be involved in the evaluation and selection of safer devices to be procured.

Needle-shielding or needle-free devices that might satisfy the occupational safety regulations for administering inject-