88 Routine maternal immunizations for all pregnant women

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The concept of adult immunization in general and maternal immunization specifically has been receiving an increased attention from clinicians and medical writers as new vaccines have come into the market. However, the general population's knowledge of the need for vaccination and which vaccines to obtain is very limited. Unfortunately, physicians who provide care to adults are also hampered by an incomplete knowledge of adult vaccines. The general public has an overall awareness of the significant reduction that has occurred in the incidence of measles, mumps, rubella, polio, diphtheria, and tetanus. However, the general public does not understand that failure to maintain immune status to diseases such as tetanus, diphtheria, hepatitis A, hepatitis B, herpes zoster, varicella influenza, pneumococcal disease, and human papillomavirus can result in serious diseases. Each of these diseases has an effective vaccine and need to be seriously considered for adult immunization.

The benefit of vaccination in pregnancy is to protect (i) the mother from disease and (ii) the neonate from disease with passive maternal antibodies. This is the best two for one deal in nature.

Active immunization is the administration of an antigen, which may be a live attenuated organism, inactivated viruses, recombinant viral particles, purified proteins, bacterial capsular polysaccharides, or exotoxin derivatives (toxoids) with the projected effect of preventing, abbreviating, or ameliorating natural infection.

Passive immunization is the transfer of performed antibodies from immune individuals by potential administration of pooled human or equine serum or by placental transfer of immunoglobulin G (IgG) from mother to fetus.

Current adult vaccines and their use in pregnancy are seen in Tables 1 and 2. Immunoglobulin G and antitoxins that are available in the United States are listed in Table 3.

Table 1 lists the vaccines that should be routine for every pregnancy. This assumes that there are universal recommendations for each of these vaccines. Table 2 lists other licensed vaccines that may be considered to be used during pregnancy in special circumstances.

VACCINATION IN PREGNANCY

It is seen from Tables 1 and 2 that a total of 6 vaccines should be used during each pregnancy and 12 vaccines that are licensed may be used if indicated. However, the vaccines that should be routinely administered to all pregnant women who have not been immunized previously are influenza, hepatitis A and hepatitis B, tetanus, diphtheria, acellular pertussis (Tdap), and pneumococcal and meningococcal vaccines. It is tragic for any pregnant women to develop an infectious disease that is vaccine preventable. This universal approach is a change in practice from ignoring the pregnant woman and assuming she

is protected to a policy of active inquiry as to her vaccine status and a program of active immunization. The result is protection of the pregnant women from disease and protection of the neonate for a variable length of time from passive maternal antibodies. The inactive vaccines and toxoids are safe to administer during pregnancy, and practicing obstetricians should adopt this positive management advance (2).

An immunization history should be obtained at the first prenatal visit. In an ideal world, the patient should be immune to measles, mumps, rubella, tetanus, diphtheria, pertussis, poliomyelitis, varicella, and hepatitis A and B. However, in the real world, adults generally are not aware of their needs for vaccination and the release of new vaccines, and many physicians are not aware of vaccine requirements. As a result of this vast lack of knowledge and information, the majority of patients are either no longer protected from disease or they have never received the appropriate vaccines.

The Advisory Committee for Immunization Practices (ACIP) at the Centers for Disease Control and Prevention (CDC) is a 15-member committee, which advises the CDC with recommendations for vaccine use. While the vaccine recommendations for pediatric vaccines are based on an age-related schedule, the adult recommendations are risk based. The risk-based strategy causes confusion for the practitioner since as many as 26 risks are identified for hepatitis B and numerous risks for other vaccines. Few physicians will remember the many risks as indications for vaccine administration. A simplified approach is to select the six important vaccines to be routinely administered during pregnancy and routinely administer these vaccines to all pregnant women as universal vaccines. A simple vaccine questionnaire is seen in Table 4. This questionnaire assumes that the six vaccines listed should be administered to all patients who have not been previously immunized, asks about allergies to vaccines, and lists whether the vaccine information statement (VIS) has been given to the patient and whether the patient has been immunized or refused immunization on the visit day. The form then becomes a record of vaccine refusal (potential medical-legal benefit), VIS given (federal requirement), and vaccine administered.

INFLUENZA EPIDEMIOLOGY

Influenza is an acute febrile illness associated with headaches, migraines, upper airway respiratory complaints, and gastrointestinal symptoms. Primary influenza pneumonia, which is frequently fatal, may occur in patients who have not been vaccinated and/or have underlying cardiopulmonary disease. Most fatalities associated with influenza are due to secondary bacterial pneumonia, usually *Streptococcus pneumoniae* (3,4). Influenza is caused by one of two viral isotypes: influenza A or influenza B. Influenza A and B are the two types that cause

epidemic human disease. Influenza A is the most common and the most virulent strain. Influenza A viruses are further characterized into subtypes based on two surface antigens, hemagglutinin (H) and neuraminidase (N). Influenza B viruses are separated into two distinct genetic lineages (Yamagata and Victoria) but cannot categorize into subtypes.

Table 1 Licensed Vaccine Recommended to All Pregnant Women

Vaccine	Type	Route	Use in pregnancy
Hepatitis B	Recombinant viral particle	IM	Yes
Hepatitis A	Killed virus	IM	Yes
Tdap	Toxoids, inactivated acellular pertussis antigens	IM	Yes
Pneumococcal	Bacterial polysaccharide	IM or SC	Yes
Influenza	Trivalent inactivated viral	IM	Yes
Meningococcal	Protein conjugate	IM	Yes

Source: From Ref. 1. Abbreviation: IM, intramuscular.

The hemagglutinin (H) antigen on the influenza A viral surface enables entry of the viral genome into the host cell. The neuraminidase (N) antigens lead to cell lysis after replication of the viral genome in a host cell. These viral antigens are critical components in the mechanisms by which influenza A viruses infect host cells and cause disease. However, the H and N antigens stimulate an immune response, acting as target antigens in developing prophylactic vaccines (5).

Influenza viruses are RNA viruses and undergo periodic genetic mutation. This alters the genetic composition of the virus allowing it to evade the natural host immunity acquired from previous exposure to vaccines or infection. The changes in the viral genome are usually minor and described as “antigenic drift.” This minor change does not result in reclassification of the viral subtype. Antigenic drift results in a novel strain that can cause disease in a naive population despite previous exposure to a genetic variant outbreak. The continual process of antigenic drift necessitates the development of new influenza A vaccines on an annual basis. Influenza B viruses are more stable and undergo antigenic drift less frequently than influenza A viruses (6).

While antigenic drift describes minor genetic changes in the viral genome, “antigenic shift” refers to major genetic alteration. The major pandemic strain in 1917 to 1918 was caused by an H1N1 subtype influenza A virus and this

Table 2 Licensed Vaccines May Be Used During Pregnancy in Special Circumstances

Vaccine	Type	Route	Circumstances for use in pregnancy
Anthrax	Inactivated bacteria	SC	For use in epidemics
BCG	Live bacteria	ID	None
Japanese encephalitis	Inactive virus	SC	Yes, if traveling to endemic area
Measles	Attenuated live virus	SC	No
Measles, mumps, rubella	Attenuated live virus	SC	No
Herpes zoster	Attenuated live virus	SC	No
Polio, inactive	Inactivated live virus (three types)	IM	Yes, if traveling to endemic area
Rabies	Inactivated virus	IM	Yes, use when indicated
Typhoid (parenteral)	Inactivated bacteria	SC	Yes, if epidemic
Typhoid (oral)	Live bacteria	Oral	No
Varicella	Attenuated live virus	SC	No, give postpartum if indicated
Yellow fever	Attenuated live virus	SC	No, use when indicated

Abbreviations: BCG, Bacillus Calmette–Guerin; ID, intradermal; IM, intramuscular; SC, subcutaneous. Source: From Ref. 1.

Table 3 Immunoglobulins and Antitoxins Available in the United States

Immunobiologic	Type	Indication
Botulinum antitoxin	Specific equine antibodies	Treatment of botulism
Cytomegalovirus Immunoglobulin (IG) intravenous	Specific human antibodies	Prophylactic for bone marrow and kidney transplants
Diphtheria antitoxin	Specific equine antibodies	Treatment of respiratory diphtheria
IG intravenous	Pooled human antibodies	A
Hepatitis B, IG	Specific human antibodies	B
Hepatitis A, IG	Specific human antibodies	C
Human rabies IG	Specific human antibodies	Suspected rabies attack
Tetanus IG	Specific human antibodies	Tetanus exposure
Varicella zoster IG	Specific human antibodies	D

All preparations are given IM except when noted (A) Replacement therapy for antibody deficit, ITP, hypogammaglobulinemia CLL. (B) Hepatitis B postexposure to infant of HBsAg-positive mother at birth. (C) Postexposure prophylaxis or pre-exposure prophylaxis. (D) Postexposure prophylaxis of susceptible persons and certain susceptible pregnant women and their exposed newborns. Abbreviations: CLL, Chronic lymphocytic leukemia; ITP, idiopathic thrombocytopenia purpura. Source: From Ref. 1.

presented until 1957 when the H2N2 subtype appeared. The H2N2 subtype underwent a major antigen shift in 1968 resulting in the H3N2, which has been circulating until the present time. An H1N1 subtype emerged in 1977 and has been co-circulating with the H3N2 subtype. Current influenza vaccine contains one H3N2 strain, one H1N1 strain, and one influenza B strain. In March 2009, a novel H1N1 subtype emerged in Mexico and is the result of influenza A strains from pigs, birds, and humans. Recombinant analysis showed triple-reassessment swine H1N1 influenza virus coming from classic swine, North American lineage; avian, North American lineage; human (seasonal) H3N2 and human seasonal (H1N1) strain initiated a worldwide pandemic (7).

INFLUENZA AND PREGNANCY

Influenza increases the risk for morbidity and mortality in all pregnant women. While increased risk of influenza-associated morbidity and mortality is present throughout pregnancy, it increases dramatically in the third trimester (3,8). Excess maternal deaths were reported during the influenza pandemic of 1917 to 1919 caused by an H1N1 subtype (9) and in 1957 to

1958 caused by an H2N2 subtype (10). Recently, it has been reported an increased risk for serious illness and hospitalization in pregnant women suffering from the respiratory complications of influenza during non-pandemic influenza seasons (11). The risk ratio for hospitalization was 5.1 among women without comorbidities and 7.9 among women with comorbidities. The relative risk for pregnant women without comorbidities rose from 1.7 in the first trimester to 5.1 in the third trimester for women with comorbidities. The relative risk for hospitalization for an influenza infection rose from 2.9 in the first trimester to 7.9 in the third trimester. ACIP and the American College of Obstetrics and Gynecologists (ACOG) have recommended that all pregnant women receive influenza vaccine during their pregnancy (4).

This pandemic H1N1 2009 influenza has shown an increased likelihood of adverse outcomes in pregnant women and has shown an increased risk of maternal mortality (3). A number of reasons for the increased morbidity and mortality of influenza A in pregnancy have been proposed. They include i) an increasing relative immunosuppression to viral antigens as the pregnancy progresses, ii) physiologic changes in pregnancy

Table 4 Office Vaccine Questionnaire

Patient name or
Facility Label

Vaccine Questionnaire

Date: _____

1. Do you have an allergy to: EGGS____ YEAST____ NEOMYCN____

Vaccine Today

Vaccine Refusal

VIS Given

2. Have you had your “FLU” shot this year? YES____ NO _____

3. Have you had your “pneumonia shot”? YES____ NO _____

4. When was your last Tetanus shot? _____

Don’t remember _____

More than 2yrs ago _____ If yes give TdaP

5. Have you had the three shot Hepatitis B series?YES____ NO____

6. Have you had the three shot Hepatitis A series?YES____ NO____

7. For ages 11–19:

Have you received the meningitis shot?YES____ NO____

with a 20% to 100% expansion of circulating blood volume having to traverse the lungs giving them a heavy quality, and iii) induction of a “cytokine storm” in patients without circulating influenza antibodies to the infectious strain (12).

It is important to remember that influenza vaccines are not teratogenic, and no convincing evidence has been published regarding fetal adverse outcomes (2). Some authors include “theoretic concerns” of fetal effects in their writing but when questioned about the theoretical risk, they are unable to locate supporting data.

ACIP and ACOG advise that all pregnant women receive trivalent inactivated influenza vaccine (TIV) at any time during the pregnancy. It is advisable to receive TIV earlier in the pregnancy so adequate time is available for the mother to develop an immune response and transfer passive antibodies to the fetus thereby protecting the fetus for the influenza season (13).

TETANUS, DIPHTHERIA, PERTUSSIS

In the minds of many people, tetanus, diphtheria, and pertussis have been thought of as being eliminated or controlled. By the 1970s, widespread implementation of tetanus diphtheria (Td) vaccine targeting pregnant women resulted in an almost universal disappearance of tetanus and diphtheria in the mother and the disappearance of neonatal tetanus when Td was used prior to or during pregnancy. Whole-cell pertussis vaccine was developed and brought into clinical practice in the late 1930s and 1940s, which led to a dramatic decrease in the incidence of pertussis. However, the number of cases of pertussis began to rise in the late 1970s primarily in adolescents and young adults. This was thought to be due to waning immunity to pertussis antigens. The vaccine available at that time was DPT and was indicated for persons up to 5 years of age. In 1992, a new formulation of DPT was developed with the introduction of “T” (full strength), “d” (reduced strength), and acellular pertussis (Tdap) for children up to 5 years of age. The acellular pertussis vaccine was significantly less reactogenic. In 2005, the Tdap vaccine was licensed for adults up to age 65 years.

Pertussis is an acute respiratory infection caused by *Bordetella pertussis*. The organism produces multiple toxins that damage the respiratory epithelium and can have symptomatic effects including lymphocytosis. *B. pertussis* infection in adolescents and adults covers a spectrum of severity from asymptomatic to a mild cough illness to classic pertussis (14).

The incubation period for pertussis is 7 to 10 days (range 5–21 days). Classic pertussis is characterized by three phases: Catarrhal, paroxysmal, and convalescent. The catarrhal phase lasts 1 to 2 weeks and consists of injection of the conjunctiva, frequent sneezing, a watery nasal discharge, and frequent cough. The cough suggests that tracheal irritation is short, hacking, isolated, and present equally day or night. Fever is uncommon during any phase.

The paroxysmal phase lasts 4 to 6 weeks. During this phase, the patient has intermittent periods of intense coughing (paroxysmal). The paroxysms are characterized by severe spasms of coughing, choking, post-tussive and inspiratory whoop. Adults and adolescents with pertussis make repeated visits for medical care and miss work and school (15,16).

Table 5 Hospitalization and Complications Among 16,431 Infants Aged <12 Months with Pertussis (2000–2005)

Complication	Number (% of total)
Hospitalization	8067 (61.7)
Apnea	7377 (56.3)
Pneumonia	1419 (12.8)
Seizures	169 (1.3)
Deaths	130 (0.8)

Source: From Ref. 17.

Table 6 Relation and Age Reported Source of Pertussis Among Infants Aged <12 Months 1999–2002

Relation	Number	%
Unknown	353	57
Mother	84	14
Father	39	6
Grandparent	22	4
Sibling	52	8
Other	67	11
Total	616	100

Source: From Ref. 18.

Pertussis is transmitted from person to person via large respiratory droplets generated by coughing or sneezing. Persons with pertussis are highly infectious especially during the catarrhal and early paroxysmal phases. Patients can remain infected for up to 6 weeks or more.

Case reports suggest that morbidity from pertussis is not increased among pregnant women as compared with non-pregnant women. Reports of fetal morbidity among pregnant women with pertussis are rare and no causal relationship with abnormal fetal development, fetal morbidity, or adverse outcome of pregnancy has been confirmed.

Unfortunately, the brunt of burden of disease occurs in the infants less than 1 year of age (Table 5). It is to be noted that apnea is a prominent finding in children admitted to the hospital. Infant deaths are characterized by an increased rate of primary and secondary pneumonia and coinfection with bacterial or viral pathogens.

The source of pertussis for the neonatal patient is largely unknown (Table 6). Although the mother is the source in 14%, the father in 6%, and grandparents and sibling in an additional 12%, immunization programs targeting mothers postpartum and their support groups are likely to be unsuccessful. The neonatal patient receives active pertussis vaccine at 2, 4, and 6 months of life and is not protected from disease until 6 months of life.

Therefore, immunization during pregnancy will protect the mother against pertussis disease and the passive antibodies that cross to the fetus will protect the neonate against disease. The newer recommendations for routine Tdap vaccinations are listed in Table 7. Tdap is recommended during the second and third trimesters and will likely need to be repeated in 10 years.

HEPATITIS B

Acute hepatitis B virus infection during pregnancy can result in severe disease for the mother and chronic infection in the

Table 7 Recommendations for Routine Tdap Vaccination

Adolescents and adults should receive a single dose of tetanus, reduced diphtheria, and acellular pertussis (Tdap) to replace a single dose of Td for active booster vaccination if they have received their last dose of Td greater than 2 years ago. Although previous recommendations have indicated 10-year intervals for Td, the interval between Td and Tdap of 2 years is now recommended for a single dose of Tdap. The American College of Obstetricians and Gynecologists recommend that Tdap may be administered during pregnancy. For those women who do not receive Tdap during pregnancy, they should be given Tdap in the postpartum period. Lactating women may receive Tdap. Health-care workers who have direct patient contact should receive a single dose of Tdap.

Source: From Ref. 14.

Table 8 Risk Groups for Preexposure Prophylaxis for Hepatitis B

All persons age 0 to 19 years
All newborns
All heterosexual persons who are not in a long-term mutually monogamous relationship
Men who have sex with men (MSM)
Injecting drug users (IDU)
All persons screened for a sexually transmitted disease
All persons tested for a sexually transmitted disease
All persons receiving hemodialysis
All persons with end-stage renal disease not on dialysis
Persons with chronic liver disease of any type
HIV-infected persons
All health-care workers
All public safety workers at risk for blood exposure or containing bodily fluids
Staff of correctional facilities
Inmates in federal, state prisons, jails, or juvenile correctional facilities
Residents of institutions for developmentally disabled
Sexual and household contacts of HBsAg-positive persons
Family members of HBsAg-positive immigrants and international adoptees
International travelers to moderate or high endemic areas
Victims of sexual assault
Persons who are not previously vaccinated or immune to HB virus infectious
Persons who desire to become vaccinated
The ACIP has published recommendation for use of Hepatitis A virus based on risk (Table 10)

Source: From Ref. 20. Abbreviation: ACIP, Advisory Committee for Immunization Practices.

Table 9 Risk Groups for Past Exposure Prophylaxis for Hepatitis B

Occupational exposure to blood or bodily fluids that contain blood
Sexual and household contacts of persons with acute hepatitis B infection
Sexual and household contacts of persons with chronic hepatitis B infection
Victims of sexual assault
Newborn infants whose mothers are HBsAg positive
Perinatal HB virus exposure

Source: From Ref. 20.

Table 10 Current Risk-Based Recommendations for Hepatitis A Vaccinations

International travelers
Men who have sex with men (MSM)
Household and sexual contacts of persons infected with HAV
Laboratory workers who handle live HAV
Laboratory workers who work with nonhuman primates
Illicit drug users (injecting and non-injecting)
Carriers of chronic hepatitis B
Persons with chronic liver diseases
Persons with clotting-factor disorders
All persons who desire protection from HAV
All public food handlers

Source: From Ref. 22.

Pregnancy should be considered an indication for the initiation of the hepatitis B vaccine series. The ACIP has recommended hepatitis B vaccine for any person, pregnant or not, who fall into any of the 22 risk groups or 6 postexposure risk groups (Tables 8 and 9).

The ACIP recommendations are complex and almost impossible to remember all the risk groups (Table 10). It is important to remember that all pregnant women are screened for six sexually transmitted diseases and all pregnant women qualify for HBV vaccine. The American Academy of Pediatrics has stated that no adverse effect to the developing fetus has been observed when pregnant women are immunized. Because severe hepatitis B virus infection can cause chronic infection in the mother and the infant, all pregnant women should be considered candidates for the HBV vaccine series if they have not been previously immunized.

Ingardi and colleagues analyzed serum antihepatitis B levels in 37 maternal serum–umbilical cord pairs following maternal vaccination (21). At the time of delivery, 18 of 37 (49%) had appropriate HBsAb levels of 10 MIU/mL or greater. The ratio of cord blood titer to maternal titer of HBgAb increased with the ratios for first, second, and third doses of vaccine were 0.55, 0.67, and 0.72 respectively. When maternal HBsAb levels exceeded 35 MIU/mL, all cord blood titers were in the seroprotective range.

HEPATITIS A VACCINE

Hepatitis A virus is transmitted through the fecal–oral route, spreading primarily through close personal contact. The acute disease is characterized by nausea, malaise, abdominal pain, and jaundice. HA virus infection does not cause chronic

neonate if a live birth occurs. Pregnancy in a woman with chronic acute hepatitis B virus infection can result in vertical transmission to the fetus and chronic infection in the neonate if no postexposure therapy occurs. The acute infection is characterized by a prolonged viremic phase that persists weeks to months. Chronic hepatitis B infections occur in 1% to 5% of adult patients with acute hepatitis B infection. Maternal infection with HBsAg positive and HBeAg positive carries a fetal transmission rate of 90%, with 50% of the neonates developing chronic hepatitis (19).

Table 11 Acute and Chronic Disease Burden Estimates for Viral Hepatitis in the United States

	Hepatitis A virus (HAV)	Hepatitis B virus (HBV)	Hepatitis C virus (HCV)
Total infection	32,000	46,000	19,000
Vaccine preventable	Yes	Yes	No
Chronic infections	NA	1 million/1.25 mil	3.2 million
Chronic liver deaths	NA	5000	8000–10,000

Source: From Ref. 24.

infection and vertical transmission has not been described. During the period 1987 to 1997, an average of 28,000 cases of hepatitis A occurred annually in the United States. After induction of hepatitis A vaccine in 1995, a significant reduction in the annual number of cases reported has occurred.

The general public perceives HAV infection as either nonserious or very mild. One has to be reminded of a large outbreak of HAV infection in fast-food restaurant in Western Pennsylvania in 2004.

More than 600 persons became ill, with 194 admissions and four deaths. The source of HAV was not the employees but imported green onions that was used to make salsa (23,24). This emphasized the vulnerability of the population to contaminated food and that universal protection is indicated. This is further indicated by the large burden of acute and chronic disease for viral hepatitis in the United States (Table 11) or that behavioral risk factors are not always predictable, thereby leaving individuals at risk until the time they come to medical attention. Importantly, the current recommendation have resulted in rates of HBV infection that are actually increasing among men aged >20 years and among women >40 years (25). Additionally, risk-based approaches have been abandoned for all pediatric vaccines and most of the adult vaccines. Unfortunately, the universal recommendations that pertain to infants, children, and adolescents have not yet been equally applied to adults (26).

Table 11 presents acute and chronic disease burdens estimated for viral hepatitis in the United States. The disease burden is great and the clinical presentation is similar for all the types of hepatitis. An active program of hepatitis A and B vaccination can be important in reducing the number of persons infected.

Problems are present with the current ACIP recommendations regarding hepatitis A and hepatitis B vaccinations. The major deficit in the current recommendations is that they are risk based and therefore likely to miss many persons at risk who would receive vaccination if the recommendation were universal. In addition, the risk categories are tedious and the majority of practitioners are unaware of multitude of risk categories. The ACIP recommendations ignore the prevailing epidemiology of these diseases. For example, <50% of patients with HAV and HBV infections do not have an identifiable risk factor for infection, specifically, whether and when an individual becomes at risk, particularly, through a lifestyle change.

Table 12 Current Advisory Committee for Immunization Practices Recommendations for Pneumococcal (PS-23) Vaccine

persons aged 65 or more
persons with surgical or functional splenectomy
person with cardiac disease
persons with pulmonary disease
persons with asthma
persons who are smokers
persons with diabetes mellitus
persons with thyroid disease
persons with renal disease
persons with metabolic syndrome
persons with chronic liver disease
persons with cerebrospinal fluid levels
persons with cochlear implants
persons who are alcoholics
persons with immunocompromised status
persons exposed to pneumococcal outbreaks
persons living in a nursing home or other long-term care facilities
persons with sickle cell disease

Source: From Ref. 28.

PNEUMOCOCCAL VACCINE

Streptococcus pneumoniae infection is a significant health problem in the United States (27). It is estimated that 3000 cases of meningitis, 500,000 cases of pneumonia, and 7 million cases of otitis media are due to the pneumococcus. This translates into 175,000 hospitalizations and an adult fatality rate of 40,000 persons per year. With aging populations, an increasing antibiotic oesistance to *S. pneumonia*, and more adults immunosuppressed, the annual number of fatalities will rise.

Pneumococcal pneumonia is the most serious clinical presentation of pneumococcal disease among adults. The incubation period is 1 to 3 days. Symptoms include an abrupt onset of fever and chills with other symptoms such as pleuritic chest pain, cough, productive of purulent, rusty sputum, dyspnea, tachypnea, hypoxia, tachycardia, malaise, and weakness.

Pneumococci account for up to 36% of adult community–acquired pneumonia and 50% of hospital-acquired pneumonia. Pneumonia is a common bacterial complication of influenza and measles. The case fatality rate is 5% to 7% and may be higher in elderly patients.

The ACIP recommendations for administration are largely risk based and therefore miss many persons (Table 12).

It is noted that there are 18 risk indications for the use of pneumococcal vaccine. The issue of risk-based recommendations is raised again as in hepatitis A and hepatitis B vaccine recommendations. The risk indication listed in Table 12 also applies to pregnant women. The VIS for pneumococcal vaccine states that there is no evidence that pneumococcal vaccine is harmful to either a pregnant women or to her fetus and women with the indications that put them at risk for pneumococcal disease should receive pneumococcal vaccine prior to pregnancy or during pregnancy (28).

MENINGOCOCCAL VACCINE

Neisseria meningitidis is the second most common cause of meningitis in the United States. Large epidemics are often the

Table 13 Immunization During Pregnancy (Active Immunization)

Vaccine	Risk from disease to pregnant women	Risk from disease to fetus or neonate	Type of immunizing agent	Risk of immunization to fetus	Indication for maternal immunization	Dose schedule	Comments
Influenza	Increase in morbidity and mortality especially during epidemic with new antigenic strain	Anatomical fetal damage, 50% mortality in neonatal disease	Trivalent inactivated vaccine (TIV)	None. Fetus receives passive antibodies from mother	All women pregnant during influenza season, any trimester	One dose annually	Passive antibodies to fetus protects from influenza
Hepatitis B	Possibly increased disease in third trimester	Increase rate, spontaneous abortion, and preterm labor. Neonatal hepatitis. High risk of chronic carrier state	Recombinant vaccine	None	All women should receive vaccine	Three dose series 0,1, 6–12 months	Birth dose strongly advised. Also HBIG for infants born of HBsAg-positive mothers
Hepatitis A	Severe morbidity, low morbidity	Increase in spontaneous abortion	Killed viral vaccine	None	All women should receive this vaccine	Two doses 0, 6–12 months	Combination HAV and HBV vaccine available
Tetanus diphtheria acellular pertussis (Tdap)	Severe morbidity tetanus morbidity 30% diphtheria mortality 10% pertussis mild morbidity	Most mortality in infants <6 months hospitalization 70% Apnea 60%	Tetanus = toxoid Diphtheria = toxoid Pertussis – 3–5 antigens	None	All pregnant women who received last Td >2 years ago	Booster single IM injection Primary 3 doses 0, 1, 6–12 months	Fetus protected with passive antibodies; immigrants usually not immunized
Pneumococcal	Severe morbidity and mortality. Increased risk of pulmonary complications	Determined by mothers' morbidity, vaccine reduces otitis media in neonate	Polyvalent polysaccharide vaccine	None	All pregnant women in 2–3 trimesters	1 dose SC or IM, repeat in 6 years for medical high risk	Reduction in otitis media first 4 months of life
Meningococcal vaccine	Severe morbidity and mortality	Determined by mothers' morbidity	Protein conjugate vaccine	None	Adolescent women International travel	One dose IM	

Abbreviations: HBIG, Hepatitis B immune globulin.

Table 14 Immunoglobulin Use in Pregnancy

Immunobiologic agents	Risk form disease in pregnant women	Risk of disease to fetus or neonate	Type of immunization agent	Risk of agent to fetus	Indication during pregnancy	Dose schedule	Comments
Measles	Significant morbidity	Increase in spontaneous abortion, may cause malformation	Standard immune globulin	None	Postexposure prophylaxis	0.25 mg/kg one dose of IG up to 15 mL	Must be given within 6 days of exposure
Hepatitis B	Increase severity in third trimester	Increase in spontaneous abortion, preterm delivery. Neonatal hepatitis, high chronic carrier rate	Hepatitis B immune globulin	None	Postexposure prophylaxis	0.06 mL/kg IM	HBV vaccine is given with HBIG if mother is HBsAg positive
Rabies	Nearly 100% fatal not altered by pregnancy	Determined by maternal disease	Rabies IG	None	Postexposure prophylaxis	20 IU/Kg ½ dose in wound ½ dose in Deltoid	Use with rabies viral vaccine
Varicella	Increase in morbidity and mortality	Congenital varicella 1–2% first trimester	Varicella immune globulin	None	Postexposure prophylaxis for mother exposure	One dose IM 125 u/10 kg Max: 625 U	Dose within 96 hours of exposure. Neonatal if mother developed varicella within 4 days before delivery or 2 days after delivery
Hepatitis A	Severe morbidity Low mortality	Increase in spontaneous abortion	Standard IG	None	Postexposure prophylaxis	One dose 0.02 mg/kg IM	Give hepatitis A vaccine with immune globulin
Rh Immunoglobulin	Death to fetus None	Rh isoimmunization with possible hydrops and deaths	Rh immune globulin	None	Rh-negative mother	One dose IM 300 mg	Administrate 28–30 weeks

Abbreviations: HBIG, Hepatitis B immune globulin.

result of infection with *N. Meningitidis* serotype A and C. A protein conjugate meningococcal vaccine (MCV4) providing protection against serotypes A, C, Y and W-135 is now available (29).

Approximately 2500 persons get meningococcal disease each year in the United States with fatality rate of 10% to 15% with another 1% to 19% losing arms or legs, becoming deaf, become mentally retarded, or suffer seizures or strokes.

MCV4 vaccine is recommended for the following persons:

- Adolescents aged 11 through 18 years
- College freshmen living in dormitories
- U.S. military recruits
- Anyone traveling to a part of the world where meningococcal disease is common
- Persons who have had a surgical splenectomy or have a functional splenectomy
- Persons with a terminal complement disorder
- Persons exposed to meningitis during an outbreak

Meningitis vaccine should be administered to adolescent pregnant women. The major vaccines that should be administered to *all* pregnant not previously immunized are summarized on Table 13. The summary of immunoglobulin that can be used in pregnancy is seen on Table 14. This chapter strongly advocates for maternal immunization as a routine to protect the mother from disease and to protect the infant with passive maternal antibodies. The shortcomings and inadequacy of the CDC's recommendations on hepatitis A and B vaccines and pneumococcal as well as Tdap are emphasized. The goal should be to prevent all vaccine preventable diseases in the mother and thereby prevent the disease in the infant by timely maternal vaccinations.

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