Neonatal group B streptococcal disease: Prevention

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Literature review current through: **Dec 2020.** | This topic last updated: **Apr 13, 2020.**

INTRODUCTION

Group B *Streptococcus* (GBS or *Streptococcus agalactiae*) is an encapsulated Gram-positive coccus that colonizes the gastrointestinal and genital tracts of 15 to 40 percent of pregnant women [1]. Although GBS colonization is asymptomatic in these women, maternal colonization is a critical determinant of infection in neonates and young infants (less than 90 days of age), in whom GBS is the most common cause of bacterial infection [2]. Vertical (mother-to-infant) transmission primarily occurs when GBS passes from the vagina into the amniotic fluid after onset of labor or rupture of membranes but can also occur with intact membranes and during passage through the birth canal [3].

In the mid-1980s, randomized and controlled clinical trials demonstrated that intrapartum intravenous administration of penicillin G or ampicillin to GBS carriers protected their newborns from developing early-onset disease (ie, GBS infection at zero to six days of age) [4-6]. Based upon this evidence, the Centers for Disease Control and Prevention published updated guidelines for prevention of neonatal GBS disease in 2002 [7] and 2010 [8], and the American College of Obstetricians and Gynecologists (ACOG) has taken on this role since 2019 [9]. The key intervention in these guidelines is intrapartum parenteral antibiotic prophylaxis of women whose infants are at risk of developing early-onset GBS infection because a maternal GBS culture was positive in the weeks before delivery or because of maternal characteristics that increase the risk of early-onset GBS disease in their offspring. Our approach is generally similar to the 2019 ACOG guidelines for prevention of early-onset GBS disease, which will be discussed here. Medical organizations in several other countries have also published guidelines. Some agree with the culture-based United States approach (eg, France), some prefer the alternative risk-based approach (eg, United Kingdom), and some allow for either culture- or risk-based identification of women suitable for intrapartum antibiotic prophylaxis. (See 'Society guideline links' below.)

The microbiology, epidemiology, clinical manifestations, and treatment of perinatal and adult GBS infections and the status of GBS vaccines are reviewed separately:

- (See "Group B streptococcal infection in pregnant women".)

- (See "Management of the infant whose mother has received group B streptococcal chemoprophylaxis".)
- (See "Group B streptococcal infection in neonates and young infants".)
- (See "Group B Streptococcus: Virulence factors and pathogenic mechanisms".)

IDENTIFICATION OF PREGNANCIES AT INCREASED RISK FOR EARLY-ONSET NEONATAL GBS

Early-onset GBS infection in the newborn results from vertical transmission. Identification of pregnancies at increased risk for vertical transmission plus appropriate intrapartum antibiotic prophylaxis can prevent early-onset GBS disease. The mortality of early-onset GBS disease is 1 to 3 percent in term infants and 20 to 30 percent in preterm infants. (See "Group B streptococcal infection in neonates and young infants", section on 'Outcome'.)

Our approach — We identify pregnancies at increased risk for vertical transmission using a culture-based approach. The alternative is a risk factor-based approach for identification. The culture-based approach to prevention of early-onset GBS involves performing routine antepartum GBS vaginal and rectal cultures on all pregnant women and administering intrapartum antibiotic prophylaxis to all colonized women. The risk factor-based approach involves identifying intrapartum women with risk factors for early-onset GBS disease in the neonate and administering antibiotic prophylaxis to these women (see 'Risk factor-based approach' below). The problem with the risk factor-based approach is that many cases of early-onset disease occur in infants of women who have no identifiable risk factors or in whom risk factors are not identified in time to provide effective chemoprophylaxis.

The value of a culture-based approach, rather than assessment of risk factors, was best demonstrated in a retrospective cohort study of deliveries in the United States from 1998 to 1999 [10]. Performing lower vaginal and rectal screening cultures at 35 to 37 weeks of gestation (1996 Centers for Disease Control and Prevention [CDC] guidelines) and administering antibiotic prophylaxis to GBS carriers were associated with a >50 percent reduction in early-onset GBS disease compared with prophylaxis based upon the presence of one or more maternal risk factors (adjusted relative risk 0.46, 95% CI 0.36-0.60). In fact, almost one in five culture-positive women did not have risk factors for early-onset neonatal infection and would not have received intrapartum antibiotic prophylaxis. Based primarily on this study, but also on results from other observational studies, the American College of Obstetricians and Gynecologists (ACOG) recommended screening cultures over risk-based screening for GBS [9].

Subsequently, a 2020 meta-analysis of studies comparing universal screening, risk-based protocols, and no policy found that [11]:

- Universal screening was associated with a reduced risk for early-onset GBS disease compared with risk-based protocols (0.3 versus 0.8 per 1000 births, risk ratio [RR] 0.43, 95% CI 0.32-0.56) or with no policy (RR 0.31, 95% CI 0.11-0.84).
- Risk-based protocols did not significantly reduce neonatal early-onset GBS disease compared with no policy (RR 0.86, 95% CI 0.61-1.20).
- In studies reporting on the use of antibiotics, universal screening was not associated with higher antibiotic administration rates compared with risk-based protocols (31 versus 29 percent).

Culture-based approach — The 2019 ACOG guidelines recommend GBS rectovaginal screening cultures for all pregnant women at 36+0 to 37+6 weeks of gestation, with the following two **exceptions** [9]:

- Women with GBS bacteriuria during the current pregnancy
- Women who previously gave birth to an infant with invasive GBS disease

These exceptions are discussed in detail below. (See 'Exceptions' below.)

Cultures are performed near/at term because many women have transient or intermittent colonization; thus, GBS colonization status in early pregnancy may not be predictive of status late in pregnancy [3,12,13]. Cultures are performed at 36+0 to 37+6 weeks of gestation because the results will be available before most women go into labor and are reasonably predictive of GBS status for approximately five weeks, at least until 41+0 weeks. Therefore, women who remain pregnant beyond their due date do not need to be recultured unless >5 weeks have elapsed since a previous negative culture. The negative predictive value of GBS cultures performed ≤5 weeks before delivery is 95 to 98 percent but declines after five weeks [13]. Between late pregnancy (35 to 37 weeks [1997 CDC protocol]) and onset of labor, GBS colonization changed from negative to positive in 3.2 percent and from positive to negative in 2.5 percent of women in a prospective population-based cohort study from Finland [14].

Women with GBS colonization should be informed of their culture results and the need to call their obstetric provider as soon as labor begins or membranes rupture.

Exceptions

- **GBS bacteriuria in current pregnancy** – Women with GBS bacteriuria any time in the current pregnancy should routinely receive intrapartum antibiotic prophylaxis, even if bacteriuria is treated and a repeat urine culture is negative; therefore, they can be excluded from culture-based screening later in pregnancy. The rationale for this recommendation is that GBS bacteriuria, especially at high levels, is a marker of heavy rectovaginal colonization (the source of GBS bacteriuria in these women), treatment of bacteriuria during pregnancy does not achieve long-term eradication of rectogenital colonization, and the neonates of women with GBS bacteriuria are at higher risk for early-onset GBS disease [12,15-17].

It should be noted that most data on the risk for early-onset GBS disease among infants born to women with GBS bacteriuria were derived from studies of GBS bacteriuria ≥10^4 or ≥10^5 CFU/mL [15,16,18]; therefore, the benefit of chemoprophylaxis in women with lower colony-count GBS bacteriuria is unproven. In 2010, the CDC recommended that laboratories report GBS in urine culture specimens when present at concentrations ≥10^4 CFU/mL in pure culture or mixed with a second microorganism [8]. The CDC stated that it is unclear how much additional disease would be prevented by screening for low colony-count GBS bacteriuria and whether identification of low colony-count bacteriuria was cost-effective.

Low-level bacteriuria is still reported by some laboratories. This author suggests that woman with low-level bacteriuria undergo GBS rectovaginal culture screening at 36+0 to 37+6 weeks of gestation and receive intrapartum antibiotic prophylaxis based on these culture results. However, an alternative approach is to routinely provide intrapartum chemoprophylaxis to women with **any** level of bacteriuria during pregnancy. The latter approach is consistent with the CDC's information sheet for clinicians, which states "we recommend that providers manage all GBS positive urine cultures equally, regardless of colony count, and consider any woman with a urine culture positive for GBS to be GBS positive for that pregnancy" [19].

Although there is expert consensus that symptomatic or asymptomatic women with GBS bacteriuria ≥10^5 CFU/mL during pregnancy should be treated according to current standards for treating bacteriuria during pregnancy, the utility of treatment at colony counts <10^5 CFU/mL is uncertain for the mother [20]. Some clinicians favor treatment of low levels of bacteriuria to prevent urinary tract and other sequelae (preterm delivery [21]), while others do not [22]. These issues are discussed in more detail separately. (See "Group B streptococcal infection in pregnant women".)

- **Delivery of an infant with early-onset GBS disease in a previous pregnancy** – There is good evidence that previous delivery of an infant with early-onset GBS disease is associated with a higher risk of early-onset disease in subsequent infants [10,23-25]. For this reason, women with this history should routinely receive intrapartum antibiotic prophylaxis and, therefore, can be excluded from culture-based screening.

Women with a history of a positive GBS culture in one or more previous pregnancies, but no infant with early-onset GBS disease, should be cultured in every pregnancy. Although a history of GBS colonization in a prior pregnancy is a risk factor for colonization in subsequent pregnancies [26-28], 50 to 60 percent of these women are not colonized in a subsequent pregnancy [28,29].

Procedure for obtaining GBS cultures — Ideally, swabs for culture should be obtained before digital examination or use of lubricants [30,31]. Both the lower vagina (vaginal introitus) and

rectum (insert swab through the anal sphincter) are sampled to achieve maximum sensitivity [32]. Either two swabs (one for each site) or a single swab can be used. The specimens may be obtained by either the health care provider or by the patient herself after appropriate instruction; studies have shown equivalent sensitivity [33-35]. Some women prefer self-sampling, and some physicians find it increases office efficiency.

A speculum should not be used to obtain the vaginal swab specimen. Sites other than the vagina and rectum (ie, cervical, periurethral, perianal, perirectal, or perineal) should not be sampled as they are less sensitive for detection of GBS and add to the cost.

The swab(s) should be placed promptly into non-nutrient transport media (eg, Amies or Stuart's without charcoal) and transported at room temperature (in temperate climates) or refrigerated [36]. The swab(s) are then transferred to a selective enrichment broth at a laboratory experienced in the isolation of GBS, incubated overnight at 37°C, and subcultured onto blood agar plates. Use of selective enrichment media substantially improves detection of GBS by enhancing GBS growth and preventing overgrowth of other organisms that may mask growth of GBS. ACOG guidelines include detailed steps for isolation and proper identification of the organism [9]. Cultures require 24 to 48 hours to show positive results, so it takes 48 hours to definitively exclude GBS.

Susceptibility testing is not necessary in most cases because GBS isolates with confirmed resistance to penicillin, ampicillin, or cefazolin have not been observed [37]. For patients with positive GBS cultures who have a serious allergy to penicillin and are candidates of intrapartum antibiotic prophylaxis, the laboratory should test for sensitivity to clindamycin. To ensure that this occurs, laboratory requisitions for urine, vaginal, and rectal cultures from pregnant women with serious penicillin allergy should be marked as such. (See 'Patients with penicillin allergy' below.)

Incidental findings noted on culture report — Some laboratories report non-GBS organisms identified in GBS screening cultures. In the only available study, group A *Streptococcus* (GAS) was present in 0.03 percent of rectovaginal cultures from pregnant women [38]. The maternal-fetal-neonatal attack rate of GAS in this setting is unknown (described in case reports [39,40]). It is probably rare because the annual incidence of invasive GAS infection in postpartum women has been estimated to be 6 per 100,000 live births in the United States [41].

We and others believe there is no clear role for preemptive treatment of asymptomatic GAS colonization identified in the course of routine prenatal care (see "Pregnancy-related group A streptococcal infection", section on 'GAS screening in pregnancy'). Opinions about management of these pregnancies vary among infectious disease experts (see "Pregnancy-related group A streptococcal infection", section on 'GAS screening in pregnancy'). As an example, a 2012 guideline for prevention and control of GAS infection in acute health care and maternity settings in the United Kingdom stated "pregnant women who are found to be infected with or carrying GAS prior to hospital admission should be treated at the time and

have this clearly documented in the maternity notes" [42]; this was an ungraded "good practice point" based on the clinical experience of the guideline development group. Consultation with an infectious disease expert may be helpful, such as in a pregnant or postpartum woman with the incidental finding of GAS on routine GBS screening culture plus risk factors for pregnancy-related GAS infection or patients with suspected GAS infection. (See "Pregnancy-related group A streptococcal infection", section on 'Diagnosis' and "Pregnancy-related group A streptococcal infection", section on 'Treatment'.)

Risk factor-based approach — As discussed above, this is not the preferred approach; the culture-based approach is preferred.

The risk factor-based approach is based on the presence of certain characteristics that are an indirect means of identifying women whose infants are at increased risk of developing early-onset disease. These risk factors can be used if culture-based screening has not been performed to identify women who should receive antibiotic prophylaxis in labor to reduce the risk of having an affected infant [43-48]:

- Intrapartum fever ≥100.4°F (≥38°C)
- Delivery before 37+0 weeks of gestation
- Rupture of membranes ≥18 hours
- Previous delivery of an infant affected by GBS disease
- GBS bacteriuria in the current pregnancy

Mathematical modeling suggests that these risk factors classify 25 to 30 percent of intrapartum women as at risk of GBS colonization, a prevalence similar to that predicted by a culture-based approach [49,50]. However, a study that compared the risk-based approach with a culture-based approach for identifying women for intrapartum antibiotic prophylaxis found that nearly 50 percent of women who delivered infants with early-onset GBS disease had none of these listed risk factors [10].

In patients with a negative GBS culture within the previous five weeks, the presence of prolonged rupture of membranes does not override the negative culture results, and GBS prophylaxis is not indicated in this setting. Appropriate antibiotic therapy would be indicated if the patient develops an intrapartum fever as this is a sign of maternal clinical infection.

Use of rapid diagnostic tests — Nucleic acid amplification test (NAAT) methodology amplifies DNA or RNA sequences using various techniques, such as polymerase chain reaction. NAATs for GBS are commercially available and can provide results in less than two hours from the time the specimen is received by the laboratory if the specimen is tested immediately.

These tests have not been universally adopted because of factors such as cost and inability to perform susceptibility testing, and they have a lower sensitivity than standard culture unless an 18- to 24-hour incubation step in selective enriched broth media is performed before NAAT. Compared with standard culture with selective broth media, the sensitivity of

NAATs performed on nonenriched samples ranges from 62.5 to 98.5 percent and 92.5 to 100 percent when performed on enriched samples (but use of enriched samples takes more time, reducing the major advantage of NAAT) [8]. Test failure rates of 7 to 10 percent have also been reported [9].

We believe that the benefits and limitations of currently available rapid NAATs do not support their use as a replacement for antenatal culture- or risk-based assessment of intrapartum women with unknown GBS status. Therefore:

- Women in labor with risk factors for GBS colonization and no antenatal GBS culture results should receive intrapartum antibiotic prophylaxis (risk factors include gestational age <37 weeks, GBS bacteriuria in current pregnancy, previous infant with GBS disease, temperature ≥100.4°F [≥38.0°C], or rupture of amniotic membranes ≥18 hours).
- For women in labor at term with no risk factors for early-onset neonatal disease and no antenatal GBS culture, NAAT is an option, where available. Using a risk factor-based approach alone, these women would not receive antibiotic prophylaxis; however, if NAAT results are positive, we would administer intrapartum antibiotic prophylaxis, similar to women with positive antenatal GBS cultures [51-53]. Those who test negative on admission NAAT would not receive antibiotic prophylaxis unless they subsequently develop fever or rupture of membranes ≥18 hours. (See 'Candidates for intrapartum antibiotic prophylaxis' below.)

Other rapid diagnostic tests have been developed, including optical immunoassays and enzyme immunoassays, but none are sufficiently sensitive when used on a direct specimen to detect GBS colonization reliably in the intrapartum setting [54].

INTRAPARTUM ANTIBIOTIC PROPHYLAXIS

Antibiotics are administered intrapartum rather than at the time of a positive culture because antibiotic administration remote from delivery does not eradicate GBS colonization at the time of delivery, which is when the infant is at risk of vertical transmission [55-57]. The intravenous route is required to achieve a rapid high concentration in maternal serum for placental transfer to the fetal systemic circulation and subsequently in amniotic fluid. Intrapartum vaginal application of chlorhexidine is not an effective method for reducing early-onset GBS disease [58].

GBS colonization is not an indication for induction or cesarean delivery; these procedures should be reserved for standard obstetric indications.

Candidates for intrapartum antibiotic prophylaxis — Intrapartum antibiotic prophylaxis is recommended in the following settings, which can be identified by laboratory testing, obstetric history, or physical examination and are predictive of an increased risk of early-onset GBS infection [9] (see 'Identification of pregnancies at increased risk for early-onset neonatal GBS' above):

- Positive screening culture for GBS from either vagina or rectum [3] **or**
- Positive history of birth of an infant with early-onset GBS disease [23-25] **or**
- GBS bacteriuria (any colony count) during the current pregnancy [15,16] **or**
- Unknown antepartum culture status (culture not performed or result not available) **plus**:
  - Intrapartum fever (≥100.4°F [≥38°C]) **or**
  - Preterm labor (<37+0 weeks of gestation) **or**
  - Preterm prelabor rupture of membranes **or**
  - Prolonged rupture of membranes (≥18 hours) [49] **or**
  - Intrapartum nucleic acid amplification test (NAAT) positive for GBS (see 'Use of rapid diagnostic tests' above)

For women with unknown antepartum culture status who have a history of GBS colonization in a previous pregnancy, the American College of Obstetricians and Gynecologists (ACOG) considers it reasonable to offer intrapartum chemoprophylaxis and to initiate a shared decision-making process as long as they have [9]:

- None of the above indications for intrapartum chemoprophylaxis, **and**
- No history of GBS bacteriuria in the current pregnancy, **and**
- No history of a previous delivery of an infant with early-onset GBS disease

However, it should be understood that cultures remote from delivery, such as in a previous pregnancy, are not predictive of culture status at delivery [10,13].

Settings where antibiotic prophylaxis for GBS is not indicated — Intrapartum antibiotic prophylaxis is **not** recommended for women with:

- Positive GBS culture in previous pregnancy but negative GBS culture within five weeks of delivery in the current pregnancy.
- Scheduled cesarean delivery – Women with a positive GBS culture who undergo scheduled cesarean delivery (at any gestational age) before onset of labor and with intact membranes are at very low risk of GBS transmission to the fetus/neonate [59]. (See 'Cesarean delivery' below.)
- Recent negative GBS culture – Pregnant women with negative GBS cultures at 36+0 to 37+6 weeks of gestation, even if they have one or more of the following intrapartum risk factors: intrapartum fever (≥100.4°F [≥38°C]), preterm labor (<37 weeks of gestation), or prolonged rupture of membranes (≥18 hours). However, the use of broad spectrum intrapartum antibiotics for treatment (not prophylaxis) is indicated for febrile women in labor if they have clinical evidence of intraamniotic infection (chorioamnionitis).

- Unknown GBS status at onset of labor, but rapid NAAT negative and no intrapartum risk factors (intrapartum fever, ≥100.4°F [≥38°C]), preterm labor (<37 weeks of gestation), or prolonged rupture of membranes (≥18 hours).

Antibiotic regimen

General principles — GBS is susceptible to penicillin G, ampicillin, extended-spectrum penicillins, cephalosporins, and vancomycin, but penicillin G is the most active agent in vitro. GBS isolates with confirmed resistance to penicillin, ampicillin, or cefazolin have not been observed [37].

Surveillance data from the United States show erythromycin resistance rates among GBS are approximately 50 to 55 percent and clindamycin resistance rates are 26 to 43 percent [60,61]. Erythromycin is no longer recommended for prophylaxis, while clindamycin use depends upon results of susceptibility tests (see 'Patients with penicillin allergy' below). Almost all isolates are resistant to trimethoprim-sulfamethoxazole [62].

Intrapartum antibiotic prophylaxis is most effective if administered at least four hours before delivery [62-65]. Although fetal serum levels of penicillin, ampicillin, or cefazolin are high within 30 minutes of a maternal intravenous infusion [66,67] and maternal vaginal GBS colony counts begin to fall promptly after beginning intravenous antibiotics, the nadir in GBS colony counts in the amniotic and vaginal fluid is not reached until approximately three hours after the first antibiotic dose [68]. In a landmark study, the rate of neonatal GBS colonization among 454 colonized mothers who delivered vaginally was 46 percent when ampicillin was administered less than one hour before delivery, 29 percent when administered one to two hours before delivery, 2.9 percent when administered two to four hours before delivery, and 1.2 percent when administered more than four hours before delivery [63]. The rate of colonization among newborns of colonized mothers who did not receive intrapartum prophylaxis was 47 percent.

Since the time of delivery cannot be predicted, prophylaxis is begun at hospital admission for labor or rupture of membranes and continued every four hours until the infant is delivered. Few studies examining the optimum duration of intrapartum antibiotic prophylaxis have been reported, but cases of early-onset neonatal disease are rare if appropriate doses of penicillin G or ampicillin are given, if four or more hours have passed between the first dose and delivery, and if no maternal infection (eg, intraamniotic infection [chorioamnionitis] or bacteremia) is present.

Medically necessary procedures should not be delayed in order to provide four hours between antibiotic administration and the procedure.

Recolonization typically occurs after cessation of therapy.

Penicillin — We agree with ACOG recommendations for penicillin dosing [9]:

- Penicillin G 5 million units intravenously initial dose, then 2.5 to 3 million units intravenously every four hours until delivery (the range of 2.5 to 3 million units

allows for the various formulations of penicillin G that are available in pharmacies).

Ampicillin 2 g intravenously initial dose, then 1 g intravenously every four hours until delivery can be used. However, penicillin G is preferred based upon its narrower spectrum of activity, which theoretically reduces the opportunity for development of ampicillin-resistant organisms. (See 'Risks of prophylaxis' below.)

Oral treatment is not recommended [9]. Absorption of oral antibiotics from the gastrointestinal tract of women in labor is not consistently reliable because delayed transit time and vomiting are common in such patients. The intravenous route is required to achieve a rapid high concentration for placental transfer. Also, high oral doses of beta-lactam antibiotics that would be required to rapidly reduce the number of organisms in the genital secretions and amniotic fluid (if colonized) to prevent neonatal infection usually cannot be tolerated by women in labor. Prospective studies have shown that oral therapy did not substantially reduce rectovaginal colonization, even in women who were not in labor [57,69].

Intramuscular therapy is also not recommended because of the lack of data of efficacy comparable to intravenous therapy [9].

Patients with penicillin allergy — The approach used in pregnant women with penicillin allergy depends upon whether their history suggests a low or high risk for anaphylaxis or the results of skin testing. (See "Choice of antibiotics in penicillin-allergic hospitalized patients", section on 'Categorize the past reaction'.)

- **Low risk for anaphylaxis** – If the patient's history suggests a "low risk" for anaphylaxis (mild reaction without features of an immediate immunoglobulin E [IgE]-mediated reaction; eg, isolated maculopapular rash without urticaria or pruritus, headache, gastrointestinal distress, pruritus without rash), we agree with ACOG recommendations [9]:
  - Cefazolin 2 g intravenously initial dose, then 1 g every eight hours until delivery.

  This recommendation is based on the ability of cefazolin to reach bactericidal concentrations in the amniotic fluid three hours after an intravenous dose.
- **High risk for anaphylaxis** – If the patient's history suggests a "high risk" for anaphylaxis (presence of features of an immediate IgE-mediated reaction; eg, anaphylaxis, immediate flushing, hypotension, angioedema, respiratory distress, urticaria, pruritic rash, particularly if these symptoms occurred within 30 minutes of drug administration), then antibiotic susceptibility testing of GBS isolates must be performed to verify susceptibility to clindamycin. Indicating on the laboratory requisition that the patient is allergic to penicillin helps to alert the laboratory of the need for this testing. If laboratory facilities are adequate, both clindamycin and erythromycin susceptibility testing are recommended. If an isolate is resistant to erythromycin, it may have inducible resistance to clindamycin, even if it appears to be susceptible to clindamycin by standard in vitro testing methods.

If a GBS isolate is resistant to erythromycin, susceptible to clindamycin, and D-zone testing for inducible resistance is negative (no inducible resistance), then we agree with ACOG recommendations [9]:

- Clindamycin 900 mg intravenously every eight hours until delivery.

If the GBS isolate is resistant to clindamycin or susceptibility results are not available, then we agree with ACOG recommendations for administration of vancomycin [9], but we use the following dose:

- Vancomycin 2 g intravenously initially and then 1 g every 12 hours thereafter until delivery. The higher initial dose is suggested to reach high peak maternal serum levels for placental transfer as quickly as possible. The maximum vancomycin dose for an adult with normal renal function is 4 g per day. If renal function is abnormal, administer the first dose as listed, but determine the timing of the next dose by measuring trough vancomycin serum level (this should be less than 15 mcg/mL before another dose is administered).
- ACOG recommendations for vancomycin dosing are 20 mg/kg (maximum single dose 2 g) intravenously every eight hours in patients with normal renal function until delivery of the infant [9]. Minimum infusion time one hour, or 500 mg/30 minutes for dose >1 g.

A study of vancomycin levels in neonatal cord blood noted therapeutic neonatal levels were usually achieved in neonates exposed to a maternal vancomycin regimen of 20 mg/kg every 8 hours (maximum individual dose 2 g) but infrequently achieved in neonates exposed to standard maternal dosing of 1 g every 12 hours (therapeutic levels: >80 versus 9 percent) [70]. However, vancomycin at 20 mg/kg every eight hours has not been evaluated for safety in pregnant women or for effectiveness in preventing early-onset GBS. Furthermore, vancomycin's pharmacokinetic profile is not favorable to achieving bactericidal concentrations in the amniotic fluid. In addition, vancomycin-resistant GBS isolates, although rare, have been reported [71]. (See "Vancomycin: Parenteral dosing, monitoring, and adverse effects in adults".)

- **Skin testing** – An alternative approach is to perform penicillin skin testing in a woman with a history of penicillin allergy to determine her allergy status [9,72]. Patients with a positive skin test are treated as high risk for anaphylaxis, as described above. Patients with negative skin tests could receive intrapartum antibiotic prophylaxis with penicillin G. However, patients with a negative skin test should avoid taking a penicillin-based drug until it is administered for intrapartum antibiotic prophylaxis, due to a small potential risk of resensitization from a subsequent course.

In 2008, 76 percent of GBS-positive women who reported to be allergic to penicillin in one large hospital received an appropriate antibiotic compared with 16 percent in 2004 to 2006 [73]. The improvement in antibiotic selection was the result of educating providers through

lectures, publicizing the Centers for Disease Control and Prevention's guidelines on posters throughout the hospital, and adding a field for "PCN allergy" to the laboratory ordering systems so that, if filled out properly, the laboratory could be automatically prompted to perform GBS sensitivity testing.

SPECIAL POPULATIONS

Preterm labor — Women admitted in preterm labor with a known positive GBS culture within the previous five weeks should be given GBS prophylaxis.

The colonization status of women admitted with preterm labor or preterm prelabor rupture of membranes generally is not known since screening is performed at 36+0 to 37+6 weeks of gestation to maximize agreement between antepartum culture results and maternal GBS status at delivery. If colonization status is unknown, GBS cultures are obtained at the time of presentation and then antibiotic prophylaxis is administered if the birth is potentially viable. If the patient is in true preterm labor, GBS prophylaxis is continued until she delivers. If after a period of observation the patient is not felt to be in true labor, GBS prophylaxis should be discontinued.

Management of subsequent episodes of preterm labor depends on final culture results at 48 hours. If the culture result is negative, no GBS prophylaxis is needed if preterm labor recurs within the next five weeks. Culture results are not predictive of GBS status for more than five weeks [13], so if preterm labor occurs more than five weeks after the negative culture, the approach is the same as that for a woman with unknown colonization status.
(See 'Candidates for intrapartum antibiotic prophylaxis' above.)

If the patient is undelivered at 36+0 to 37+6 weeks of gestation, a vaginal-rectal culture should be repeated to predict GBS status and guide management at term.

Preterm prelabor rupture of membranes — Women with intraamniotic infection (chorioamnionitis) typically receive broad spectrum antibiotic therapy. This therapy should include an agent known to be active against GBS (typically a penicillin or cephalosporin) to replace GBS prophylaxis.
Women with preterm prelabor rupture of membranes undergoing expectant management and given antibiotic prophylaxis during the latency period should receive a regimen that includes prophylaxis for GBS after specimens for GBS culture have been obtained. GBS prophylaxis is discontinued if the cultures are negative for GBS. The management of these patients is discussed separately. (See "Preterm prelabor rupture of membranes: Management and outcome", section on 'GBS'.)

In an observational study of 33 GBS carriers with preterm prelabor rupture of membranes receiving penicillin G prophylaxis, daily genital tract cultures for GBS were negative in 29/33 patients (88 percent) by day 1, in 32/33 patients by day 2, and in all 33 patients by day 3 [74].

Term prelabor rupture of membranes — Women at term with GBS colonization who rupture membranes before labor begins are advised to come to the hospital, so GBS antibiotic prophylaxis can be initiated. In some of these women, GBS colonization may have been the cause of membrane rupture, and invasion of the amniotic fluid may have already begun. Although we favor prompt induction of women with ruptured membranes at term, some providers and women favor expectant management. If expectant management is undertaken, hospitalization for maternal antibiotic prophylaxis against early-onset neonatal GBS disease should still be initiated immediately. (See "Management of prelabor rupture of the fetal membranes at term", section on 'Group B streptococcus colonization'.)

Women undergoing obstetric procedures

Antepartum procedures — There are no high-quality data about the usefulness of antibiotic prophylaxis of antepartum obstetric procedures in women colonized with GBS or in those in whom GBS status is unknown [9]. Such procedures include vaginal examination, mechanical and pharmacologic cervical ripening, and membrane stripping/sweeping. In the absence of such data, we suggest not avoiding these procedures when clinically indicated and not administering prophylactic antibiotics.

- A prospective study that compared maternal and neonatal outcomes following membrane stripping/sweeping for induction among GBS-positive (n = 135), GBS-negative (n = 361), and GBS-unknown (n = 46) patients found no significant difference in adverse maternal or neonatal outcomes between groups [1]. There was no difference in the rate of possible early-onset neonatal infection between the GBS-positive and GBS-negative groups and no cases of neonatal sepsis in the entire cohort. Most GBS-positive women received intrapartum GBS antibiotic prophylaxis.
- In addition, two small trials available only in abstract form examined membrane sweeping in GBS-positive women and found that the procedure did not result in additional maternal or fetal risk [75].

Although these results are reassuring about the safety of membrane stripping in GBS-positive women, the studies did not have adequate power to detect modest differences in outcome, the prospective study is subject to the limitations of an observational design, and the trials did not provide adequate data for careful assessment.

Intrapartum procedures — There is no evidence that intrapartum vaginal examinations and other clinically indicated invasive procedures (eg, placement of a fetal scalp electrode, amniotomy) increase the risk of early-onset GBS infection in infants of women who are known to be colonized, although data on transmission risk in these settings are limited [76].

Ideally, amniotomy and other invasive procedures are performed at least four hours after intrapartum antibiotic prophylaxis has been initiated because the nadir in GBS colony counts in the amniotic and vaginal fluid is not reached until approximately three hours after the first antibiotic dose; however, these procedures should not be delayed to achieve an optimal antibiotic concentration when there is a medically or obstetrically urgent need for them.

Cesarean delivery — GBS colonization is not an appropriate indication for cesarean delivery; cesarean delivery should be performed for standard medical/obstetric indications. As discussed above, women with a positive GBS culture who undergo scheduled cesarean delivery at any gestational age without labor or rupture of membranes do not require GBS prophylaxis because the risk of GBS transmission to the fetus/neonate is very low in this setting [9,59].

Patients planning cesarean delivery should undergo routine vaginal and rectal screening for GBS at 36+0 to 37+6 weeks because onset of labor or rupture of membranes may occur before the planned cesarean delivery, which is typically at ≥39 weeks. Either of these events increases the risk of GBS transmission and, therefore, would be an indication for standard intrapartum antibiotic prophylaxis. (See 'Antibiotic regimen' above.)

An urgent cesarean delivery should not be delayed to achieve ≥4 hours of intrapartum antibiotic prophylaxis before the procedure.

OUTCOME

Maternal intrapartum GBS chemoprophylaxis has resulted in a significant reduction in early-onset GBS disease (>80 percent of cases) and neonatal death [60,77,78]. The incidence of late-onset GBS disease has remained stable [79].

Early-onset GBS — A 2014 Cochrane review of randomized trials of intrapartum antibiotic treatment of women colonized with GBS found that, compared with no treatment, intrapartum antibiotic prophylaxis resulted in an 80 percent reduction in early-onset neonatal GBS infection (odds ratio 0.17, 95% CI 0.04-0.74) and a similar, although not statistically significant, reduction in neonatal mortality (all-cause mortality risk ratio [RR] 0.19, 95% CI 0.01-3.92; mortality from early-onset GBS RR 0.31, 95% CI 0.01-7.50) [78].

In the United States, widespread use of GBS screening and intrapartum antibiotic prophylaxis has resulted in a substantial decrease in early-onset GBS infections (ie, diagnosis of neonatal GBS infection within six days after birth), as illustrated below:

- In 1993, before active efforts at prevention, the incidence of early-onset GBS infection was estimated to be 1.5 per 1000 live births [7].
- After publication of the 1996 recommendations for GBS prophylaxis (risk factor-based approach), the incidence of early-onset GBS fell to 0.52 per 1000 live births by 2000.

- In 2002, adoption of universal culture-based screening was associated with a further drop in early-onset GBS to 0.31 cases per 1000 live births in 2003, a rise to 0.40 cases per 1000 live births in 2006, and then a fall to 0.24 cases per 1000 live births in 2010 [8,80,81]. The rise from 2003 to 2006 was mostly due to a significant increase in early-onset disease among term black infants (from 0.33 to 0.70 cases per 1000 live births).
- From 2005 to 2014, GBS was the most common cause of early-onset neonatal sepsis. The incidence was generally stable but fell from 0.27 per 1000 live births in 2005 to 0.22 per 1000 live births in 2014 ($p = 0.02$), with a higher incidence at birth weight <1500 g [82].
- The most recent data from 2016 indicate the incidence of early-onset GBS is 0.22 per 1000 live births [83].

Late-onset GBS — In the United States, the incidence of late-onset GBS infection (7 to 89 days after birth) has remained stable at an average 0.35 cases per 1000 live births [81]. The incidence of late-onset GBS infection in Europe appears to be similar to, or slightly lower than, that in the United States but is less well-defined because most European studies have not performed population-based active surveillance of culture-confirmed invasive infection [84]. The most recent data from the United States in 2016 report a late-onset disease incidence of 0.25 per 1000 live births.

LIMITATIONS OF GBS PREVENTION PROGRAMS

Neonatal GBS infection continues to occur in the United States, in part, because of nonadherence to the Centers for Disease Control and Prevention's prenatal screening and intrapartum prophylaxis guidelines [85,86] and, in part, because some women colonized at delivery are not identified despite screening.

These women are not identified by screening because approximately 4 percent of women who test negative at 35 to 37 weeks of gestation (older culture-based protocol) have a "false-negative" test result (ie, screening culture is negative but newborn develops early-onset GBS disease), and approximately 60 percent of early-onset GBS occurs in these women [13,87-89]. In a retrospective review of 254 cases of early-onset GBS among 7691 live births from a multistate GBS surveillance system, approximately 75 percent of GBS cases (189/254) occurred in term infants, but only approximately one-fifth of these cases (37/189) occurred in women whose screen results were positive; 116 cases (61.4 percent) occurred in women whose screen results were negative, 34 cases (13.4 percent) were attributed to no screening, and 2 cases occurred in women whose screen results were not known [88].

The methods used for processing screening cultures in these studies were not described and may have affected the results. These findings suggest that more sensitive methods of detection would be useful.

RISKS OF PROPHYLAXIS

There is a theoretic possibility that extensive use of intrapartum prophylaxis could result in increased antibiotic resistance among GBS isolates and/or an increased incidence of infections due to other pathogens. Thus far, no consistent trends have been identified [90-99]. A population-based GBS surveillance program in 10 states tested 4882 GBS isolates and found that 100 percent were sensitive to penicillin, ampicillin, and vancomycin, but 32 percent were resistant to erythromycin, and 15 percent were resistant to clindamycin [100]. Susceptibility to first-generation cephalosporins was not assessed; however, a similar population-based surveillance study reported all GBS isolates were susceptible to cefazolin [101].

Exposure to broad spectrum intrapartum antibiotic prophylaxis has been associated with an increased risk of late-onset serious bacterial infections and infection with resistant organisms [95,102,103]. In addition, clindamycin, broad spectrum cephalosporins, and broad spectrum penicillins can lead to *Clostridioides* (formerly *Clostridium*) *difficile* colitis. These findings support the recommendation to use penicillin G as the preferred agent for GBS prophylaxis rather than broader spectrum antibiotics such as ampicillin. (See "Clostridioides (formerly Clostridium) difficile infection in adults: Epidemiology, microbiology, and pathophysiology".)

NEWBORNS

Preventive strategies after birth — A prevention strategy targeting newborns, rather than maternal colonization, is not recommended. Although large observational studies have suggested that administration of intramuscular penicillin G to the newborn immediately after delivery may reduce early-onset GBS disease [104,105], a nonblinded randomized trial involving 1187 infants failed to identify a benefit in outcome of GBS disease or neonatal mortality [106].

The discrepancy between the results of the observational studies and the randomized trial may be explained by methodologic issues [107]. The randomized trial may not have included sufficient numbers of patients to detect a difference in outcome between treated and control infants. In addition, the participants in the randomized trial were preterm low birth weight infants who were transferred to a neonatal intensive care unit. Twenty of 24 infected babies showed signs of sepsis within the first hour of life, suggesting that infection may have been present at the time of delivery. Finally, there were differences in general management that may have contributed to the discrepant findings. Unless high quality evidence becomes available, the standard for prevention of early-onset GBS disease is maternal rather than newborn chemoprophylaxis.

Management of newborns — Management of newborns is discussed separately.

- (See "Management of the infant whose mother has received group B streptococcal chemoprophylaxis".)
- (See "Group B streptococcal infection in neonates and young infants".)

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Sepsis in neonates" and "Society guideline links: Group B streptococcal infection in pregnant women and neonates".)

INFORMATION FOR PATIENTS

UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Basics topics (see "Patient education: Group B streptococcal disease (The Basics)")
- Beyond the Basics topics (see "Patient education: Group B streptococcus and pregnancy (Beyond the Basics)")

SUMMARY AND RECOMMENDATIONS

- Maternal Group B streptococcal (GBS) colonization occurs in 15 to 40 percent of women and is the critical determinant of early-onset GBS infection in neonates less than seven days of age. (See 'Introduction' above.)
- We suggest universal rather than risk-based or no screening of pregnant women to identify those who carry GBS (**Grade 2B**). Colonized women can transmit GBS to offspring, resulting in early-onset disease in neonates, and approximately one-half of these cases will be missed if a selective risk factor-based approach is taken. Administration of intrapartum antibiotics to colonized women reduces the occurrence of early-onset GBS infection in their neonates. (See 'Identification of

pregnancies at increased risk for early-onset neonatal GBS' above and 'Early-onset GBS' above and 'Intrapartum antibiotic prophylaxis' above.)

- We recommend obtaining GBS cultures at 36+0 to 37+6 weeks of gestation. Cultures obtained more than five weeks before delivery are less sensitive in predicting GBS status at the time of birth. Women with GBS bacteriuria any time in pregnancy (**Grade 2B**) or an infant with early-onset GBS infection in a previous pregnancy (**Grade 2C**) should routinely receive intrapartum antibiotic prophylaxis; therefore, they can be excluded from culture-based screening. (See 'Culture-based approach' above and 'Exceptions' above.)
- Swabs for GBS culture should be obtained from both the lower vagina (introitus not cervix) and rectum (not the anal orifice) to achieve maximum sensitivity; these should be placed in transport media, sent to the laboratory, and inoculated into selective broth media for incubation and further processing. (See 'Procedure for obtaining GBS cultures' above.)
- Laboratory requisitions for urine, vaginal, and rectal cultures from pregnant women with penicillin allergy should be marked accordingly so that appropriate sensitivity testing is performed. (See 'Procedure for obtaining GBS cultures' above.)
- In women with positive GBS vaginal-rectal cultures undergoing a planned cesarean delivery before onset of labor and with intact membranes, we recommend **not** administering intrapartum antibiotic prophylaxis, given the low risk of early-onset disease (**Grade 1B**). (See 'Intrapartum antibiotic prophylaxis' above and 'Outcome' above.)
- Women with intrapartum fever (≥100.4°F [≥38°C]) whose culture status is unknown (culture not performed or result not available) should receive intrapartum antibiotic treatment (not prophylaxis) that includes an agent active against GBS. (See 'Intrapartum antibiotic prophylaxis' above and 'Outcome' above.)
- The colonization status of women who present with threatened preterm delivery generally is not known. In these women, we obtain a GBS rectovaginal culture and give intravenous antibiotic prophylaxis. Continuation of therapy is then guided by culture results and uterine activity. Antibiotic therapy is continued until delivery or until the threat of imminent preterm delivery has passed. (See 'Special populations' above.)
- For women in labor with unknown antepartum culture status, we recommend intrapartum antibiotic prophylaxis if the gestation is less than 37 weeks, or the duration of membrane rupture is ≥18 hours, or preterm prelabor rupture of membranes occurred, or an intrapartum nucleic acid amplification test is positive for GBS. Maternal temperature ≥100.4°F (≥38.0°C) is suggestive of infection and should be treated with antibiotics that provide activity against GBS. (See 'Candidates for intrapartum antibiotic prophylaxis' above.)

- For women with unknown antepartum culture status who have a history of GBS colonization in a previous pregnancy but no risk factors for early-onset disease in offspring in the current pregnancy, the American College of Obstetricians and Gynecologists (ACOG) considers it reasonable to offer intrapartum chemoprophylaxis in a shared decision-making process. (See 'Candidates for intrapartum antibiotic prophylaxis' above.)
- Intrapartum antibiotic prophylaxis is most effective if penicillin G, ampicillin, or cefazolin is administered intravenously at least four hours before delivery. (See 'General principles' above.)
- In women without penicillin allergy, penicillin G is the preferred drug for prophylaxis, given its low cost, low incidence of side effects, and uniform GBS susceptibility. We administer a dose of 5 million units intravenously initially, then 2.5 to 3 million units intravenously every four hours until delivery, in agreement with ACOG guidelines. Ampicillin 2 g intravenously initial dose then 1 g every four hours until delivery is an acceptable alternative. (See 'Antibiotic regimen' above.)
- In patients with a non-serious penicillin allergy, cefazolin is recommended in place of penicillin G. (See 'Patients with penicillin allergy' above.)
- In patients with penicillin allergy at risk for anaphylaxis, clindamycin is recommended **if** susceptibility testing has been performed and sensitivity to clindamycin is documented. If the GBS isolate is resistant to clindamycin or susceptibility results are not available, we suggest vancomycin 2 g intravenously initially and then 1 g every 12 hours thereafter until delivery rather than the ACOG recommendation for 20 mg/kg (maximum 2 g) intravenously every eight hours until delivery (**Grade 2C**) in patients with normal renal function. Neither clindamycin nor vancomycin has been evaluated for effectiveness in preventing early-onset GBS infant disease. (See 'Patients with penicillin allergy' above.)
  Note, resistance to erythromycin is often associated with clindamycin resistance. If an isolate is resistant to erythromycin, it may have inducible resistance to clindamycin, even if it appears to be susceptible to clindamycin by standard in vitro testing methods. If a GBS isolate is resistant to erythromycin, susceptibility to clindamycin should be confirmed by D-zone testing for inducible resistance. If negative (no inducible resistance), then clindamycin can be used for GBS intrapartum prophylaxis. (See 'Patients with penicillin allergy' above.)
- Antepartum antibiotic treatment of GBS colonization remote from delivery should be avoided as it does not reduce the incidence of GBS colonization at the time of delivery. (See 'Intrapartum antibiotic prophylaxis' above.)

REFERENCES

1. Regan JA, Klebanoff MA, Nugent RP. The epidemiology of group B streptococcal colonization in pregnancy. Vaginal Infections and Prematurity Study Group. Obstet Gynecol 1991; 77:604.
2. Baker CJ, Barrett FF. Transmission of group B streptococci among parturient women and their neonates. J Pediatr 1973; 83:919.
3. Boyer KM, Gadzala CA, Kelly PD, et al. Selective intrapartum chemoprophylaxis of neonatal group B streptococcal early-onset disease. II. Predictive value of prenatal cultures. J Infect Dis 1983; 148:802.
4. Boyer KM, Gotoff SP. Prevention of early-onset neonatal group B streptococcal disease with selective intrapartum chemoprophylaxis. N Engl J Med 1986; 314:1665.
5. Easmon CS, Hastings MJ, Deeley J, et al. The effect of intrapartum chemoprophylaxis on the vertical transmission of group B streptococci. Br J Obstet Gynaecol 1983; 90:633.
6. Boyer KM, Gadzala CA, Kelly PD, Gotoff SP. Selective intrapartum chemoprophylaxis of neonatal group B streptococcal early-onset disease. III. Interruption of mother-to-infant transmission. J Infect Dis 1983; 148:810.
7. Schrag S, Gorwitz R, Fultz-Butts K, Schuchat A. Prevention of perinatal group B streptococcal disease. Revised guidelines from CDC. MMWR Recomm Rep 2002; 51:1.
8. Verani JR, McGee L, Schrag SJ, Division of Bacterial Diseases, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention (CDC). Prevention of perinatal group B streptococcal disease--revised guidelines from CDC, 2010. MMWR Recomm Rep 2010; 59:1.
9. Prevention of Group B Streptococcal Early-Onset Disease in Newborns: ACOG Committee Opinion, Number 797. Obstet Gynecol 2020; 135:e51.
10. Schrag SJ, Zell ER, Lynfield R, et al. A population-based comparison of strategies to prevent early-onset group B streptococcal disease in neonates. N Engl J Med 2002; 347:233.
11. Hasperhoven GF, Al-Nasiry S, Bekker V, et al. Universal screening versus risk-based protocols for antibiotic prophylaxis during childbirth to prevent early-onset group B streptococcal disease: a systematic review and meta-analysis. BJOG 2020; 127:680.
12. Regan JA, Klebanoff MA, Nugent RP, et al. Colonization with group B streptococci in pregnancy and adverse outcome. VIP Study Group. Am J Obstet Gynecol 1996; 174:1354.
13. Yancey MK, Schuchat A, Brown LK, et al. The accuracy of late antenatal screening cultures in predicting genital group B streptococcal colonization at delivery. Obstet Gynecol 1996; 88:811.
14. Virranniemi M, Raudaskoski T, Haapsamo M, et al. The effect of screening-to-labor interval on the sensitivity of late-pregnancy culture in the prediction of

group B streptococcus colonization at labor: A prospective multicenter cohort study. Acta Obstet Gynecol Scand 2019; 98:494.
15. Persson K, Christensen KK, Christensen P, et al. Asymptomatic bacteriuria during pregnancy with special reference to group B streptococci. Scand J Infect Dis 1985; 17:195.
16. Wood EG, Dillon HC Jr. A prospective study of group B streptococcal bacteriuria in pregnancy. Am J Obstet Gynecol 1981; 140:515.
17. Yancey MK, Duff P, Kubilis P, et al. Risk factors for neonatal sepsis. Obstet Gynecol 1996; 87:188.
18. Persson K, Bjerre B, Elfström L, et al. Group B streptococci at delivery: high count in urine increases risk for neonatal colonization. Scand J Infect Dis 1986; 18:525.
19. https://www.cdc.gov/groupbstrep/clinicians/qas-obstetric.html (Accessed on Ma rch 11, 2019).
20. Aungst M, King J, Steele A, Gordon M. Low colony counts of asymptomatic group B streptococcus bacteriuria: a survey of practice patterns. Am J Perinatol 2004; 21:403.
21. Thomsen AC, Mørup L, Hansen KB. Antibiotic elimination of group-B streptococci in urine in prevention of preterm labour. Lancet 1987; 1:591.
22. Allen VM, Yudin MH, Bouchard C, et al. Management of group B streptococcal bacteriuria in pregnancy. J Obstet Gynaecol Can 2012; 34:482.
23. Christensen KK, Dahlander K, Lindén V, et al. Obstetrical care in future pregnancies after fetal loss in group B streptococcal septicemia. A prevention program based on bacteriological and immunological follow-up. Eur J Obstet Gynecol Reprod Biol 1981; 12:143.
24. Faxelius G, Bremme K, Kvist-Christensen K, et al. Neonatal septicemia due to group B streptococci--perinatal risk factors and outcome of subsequent pregnancies. J Perinat Med 1988; 16:423.
25. Carstensen H, Christensen KK, Grennert L, et al. Early-onset neonatal group B streptococcal septicaemia in siblings. J Infect 1988; 17:201.
26. Turrentine MA, Ramirez MM. Recurrence of group B streptococci colonization in subsequent pregnancy. Obstet Gynecol 2008; 112:259.
27. Page-Ramsey SM, Johnstone SK, Kim D, Ramsey PS. Prevalence of group B Streptococcus colonization in subsequent pregnancies of group B Streptococcus-colonized versus noncolonized women. Am J Perinatol 2013; 30:383.
28. Cheng PJ, Chueh HY, Liu CM, et al. Risk factors for recurrence of group B streptococcus colonization in a subsequent pregnancy. Obstet Gynecol 2008; 111:704.
29. Colicchia LC, Lauderdale DS, Du H, et al. Recurrence of group B streptococcus colonization in successive pregnancies. J Perinatol 2015; 35:173.

30. Knudtson EJ, Lorenz LB, Skaggs VJ, et al. The effect of digital cervical examination on group B streptococcal culture. Am J Obstet Gynecol 2010; 202:58.e1.
31. Schwope OI, Chen KT, Mehta I, et al. The effect of a chlorhexidine-based surgical lubricant during pelvic examination on the detection of group B Streptococcus. Am J Obstet Gynecol 2010; 202:276.e1.
32. Badri MS, Zawaneh S, Cruz AC, et al. Rectal colonization with group B streptococcus: relation to vaginal colonization of pregnant women. J Infect Dis 1977; 135:308.
33. Price D, Shaw E, Howard M, et al. Self-sampling for group B streptococcus in women 35 to 37 weeks pregnant is accurate and acceptable: a randomized cross-over trial. J Obstet Gynaecol Can 2006; 28:1083.
34. Hicks P, Diaz-Perez MJ. Patient self-collection of group B streptococcal specimens during pregnancy. J Am Board Fam Med 2009; 22:136.
35. Arya A, Cryan B, O'Sullivan K, et al. Self-collected versus health professional-collected genital swabs to identify the prevalence of group B streptococcus: a comparison of patient preference and efficacy. Eur J Obstet Gynecol Reprod Biol 2008; 139:43.
36. Larsen JW, Sever JL. Group B Streptococcus and pregnancy: a review. Am J Obstet Gynecol 2008; 198:440.
37. Andrews JI, Diekema DJ, Hunter SK, et al. Group B streptococci causing neonatal bloodstream infection: antimicrobial susceptibility and serotyping results from SENTRY centers in the Western Hemisphere. Am J Obstet Gynecol 2000; 183:859.
38. Mead PB, Winn WC. Vaginal-rectal colonization with group A streptococci in late pregnancy. Infect Dis Obstet Gynecol 2000; 8:217.
39. Stefonek KR, Maerz LL, Nielsen MP, et al. Group A streptococcal puerperal sepsis preceded by positive surveillance cultures. Obstet Gynecol 2001; 98:846.
40. Hamilton SM, Stevens DL, Bryant AE. Pregnancy-related group a streptococcal infections: temporal relationships between bacterial acquisition, infection onset, clinical findings, and outcome. Clin Infect Dis 2013; 57:870.
41. Chuang I, Van Beneden C, Beall B, Schuchat A. Population-based surveillance for postpartum invasive group a streptococcus infections, 1995-2000. Clin Infect Dis 2002; 35:665.
42. Steer JA, Lamagni T, Healy B, et al. Guidelines for prevention and control of group A streptococcal infection in acute healthcare and maternity settings in the UK. J Infect 2012; 64:1.
43. Adair CE, Kowalsky L, Quon H, et al. Risk factors for early-onset group B streptococcal disease in neonates: a population-based case-control study. CMAJ 2003; 169:198.

44. Oddie S, Embleton ND. Risk factors for early onset neonatal group B streptococcal sepsis: case-control study. BMJ 2002; 325:308.
45. Zaleznik DF, Rench MA, Hillier S, et al. Invasive disease due to group B Streptococcus in pregnant women and neonates from diverse population groups. Clin Infect Dis 2000; 30:276.
46. Schuchat A, Zywicki SS, Dinsmoor MJ, et al. Risk factors and opportunities for prevention of early-onset neonatal sepsis: a multicenter case-control study. Pediatrics 2000; 105:21.
47. Schuchat A, Deaver-Robinson K, Plikaytis BD, et al. Multistate case-control study of maternal risk factors for neonatal group B streptococcal disease. The Active Surveillance Study Group. Pediatr Infect Dis J 1994; 13:623.
48. Boyer KM, Gadzala CA, Burd LI, et al. Selective intrapartum chemoprophylaxis of neonatal group B streptococcal early-onset disease. I. Epidemiologic rationale. J Infect Dis 1983; 148:795.
49. Boyer KM, Gotoff SP. Strategies for chemoprophylaxis of GBS early-onset infections. Antibiot Chemother (1971) 1985; 35:267.
50. Rouse DJ, Goldenberg RL, Cliver SP, et al. Strategies for the prevention of early-onset neonatal group B streptococcal sepsis: a decision analysis. Obstet Gynecol 1994; 83:483.
51. Khalil MR, Uldbjerg N, Thorsen PB, Møller JK. Intrapartum PCR assay versus antepartum culture for assessment of vaginal carriage of group B streptococci in a Danish cohort at birth. PLoS One 2017; 12:e0180262.
52. Abdelazim IA. Intrapartum polymerase chain reaction for detection of group B streptococcus colonisation. Aust N Z J Obstet Gynaecol 2013; 53:236.
53. Tanaka K, Iwashita M, Matsushima M, et al. Intrapartum group B Streptococcus screening using real-time polymerase chain reaction in Japanese population. J Matern Fetal Neonatal Med 2016; 29:130.
54. Honest H, Sharma S, Khan KS. Rapid tests for group B Streptococcus colonization in laboring women: a systematic review. Pediatrics 2006; 117:1055.
55. Centers for Disease Control and Prevention (CDC). Laboratory practices for prenatal Group B streptococcal screening and reporting--Connecticut, Georgia, and Minnesota, 1997-1998. MMWR Morb Mortal Wkly Rep 1999; 48:426.
56. Klebanoff MA, Regan JA, Rao AV, et al. Outcome of the Vaginal Infections and Prematurity Study: results of a clinical trial of erythromycin among pregnant women colonized with group B streptococci. Am J Obstet Gynecol 1995; 172:1540.
57. Gardner SE, Yow MD, Leeds LJ, et al. Failure of penicillin to eradicate group B streptococcal colonization in the pregnant woman. A couple study. Am J Obstet Gynecol 1979; 135:1062.

58. Ohlsson A, Shah VS, Stade BC. Vaginal chlorhexidine during labour to prevent early-onset neonatal group B streptococcal infection. Cochrane Database Syst Rev 2014; :CD003520.
59. Ramus RM, McIntire DD, Wendel GD Jr. Antibiotic chemoprophylaxis for group B strep is not necessary with elective cesarean section at term [Abstract]. Am J Obstet Gynecol 1999; 180:S85.
60. Nanduri SA, Petit S, Smelser C, et al. Epidemiology of Invasive Early-Onset and Late-Onset Group B Streptococcal Disease in the United States, 2006 to 2015: Multistate Laboratory and Population-Based Surveillance. JAMA Pediatr 2019; 173:224.
61. Francois Watkins LK, McGee L, Schrag SJ, et al. Epidemiology of Invasive Group B Streptococcal Infections Among Nonpregnant Adults in the United States, 2008-2016. JAMA Intern Med 2019; 179:479.
62. Edwards MS, Nizet V, Baker CJ. Group B Streptococcal Infections. In: Remington and Klein's Infectious Diseases of the Fetus and Newborn Infant, 8th ed, Wilson CB, Nizet V, Maldonado YA, et al (Eds), Elsevier, Philadelphia 2016. p.411.
63. de Cueto M, Sanchez MJ, Sampedro A, et al. Timing of intrapartum ampicillin and prevention of vertical transmission of group B streptococcus. Obstet Gynecol 1998; 91:112.
64. Fairlie T, Zell ER, Schrag S. Effectiveness of intrapartum antibiotic prophylaxis for prevention of early-onset group B streptococcal disease. Obstet Gynecol 2013; 121:570.
65. Turrentine MA, Greisinger AJ, Brown KS, et al. Duration of intrapartum antibiotics for group B streptococcus on the diagnosis of clinical neonatal sepsis. Infect Dis Obstet Gynecol 2013; 2013:525878.
66. Barber EL, Zhao G, Buhimschi IA, Illuzzi JL. Duration of intrapartum prophylaxis and concentration of penicillin G in fetal serum at delivery. Obstet Gynecol 2008; 112:265.
67. Pacifici GM. Placental transfer of antibiotics administered to the mother: a review. Int J Clin Pharmacol Ther 2006; 44:57.
68. McNanley AR, Glantz JC, Hardy DJ, Vicino D. The effect of intrapartum penicillin on vaginal group B streptococcus colony counts. Am J Obstet Gynecol 2007; 197:583.e1.
69. Baecher L, Grobman W. Prenatal antibiotic treatment does not decrease group B streptococcus colonization at delivery. Int J Gynaecol Obstet 2008; 101:125.
70. Onwuchuruba CN, Towers CV, Howard BC, et al. Transplacental passage of vancomycin from mother to neonate. Am J Obstet Gynecol 2014; 210:352.e1.
71. Park C, Nichols M, Schrag SJ. Two cases of invasive vancomycin-resistant group B streptococcus infection. N Engl J Med 2014; 370:885.

72. Macy E. Penicillin skin testing in pregnant women with a history of penicillin allergy and group B streptococcus colonization. Ann Allergy Asthma Immunol 2006; 97:164.
73. Critchfield AS, Lievense SP, Raker CA, Matteson KA. Group B Streptococcus prophylaxis in patients who report a penicillin allergy: a follow-up study. Am J Obstet Gynecol 2011; 204:150.e1.
74. Alvarez JR, Williams SF, Ganesh VL, Apuzzio JJ. Duration of antimicrobial prophylaxis for group B streptococcus in patients with preterm premature rupture of membranes who are not in labor. Am J Obstet Gynecol 2007; 197:390.e1.
75. Finucane EM, Murphy DJ, Biesty LM, et al. Membrane sweeping for induction of labour. Cochrane Database Syst Rev 2020; 2:CD000451.
76. Gibbs RS, Schrag S, Schuchat A. Perinatal infections due to group B streptococci. Obstet Gynecol 2004; 104:1062.
77. Edmond KM, Kortsalioudaki C, Scott S, et al. Group B streptococcal disease in infants aged younger than 3 months: systematic review and meta-analysis. Lancet 2012; 379:547.
78. Ohlsson A, Shah VS. Intrapartum antibiotics for known maternal Group B streptococcal colonization. Cochrane Database Syst Rev 2014; :CD007467.
79. https://www.cdc.gov/abcs/reports-findings/survreports/gbs12.html#modalIdString_CDCTable_3 (Accessed on July 07, 2017).
80. Centers for Disease Control and Prevention (CDC). Trends in perinatal group B streptococcal disease - United States, 2000-2006. MMWR Morb Mortal Wkly Rep 2009; 58:109.
81. Centers for Disease Control and Prevention (2008) Active Bacterial Core Surveillance Report, Emerging Infections Program Network, Group B Streptococcus, 2007. http://www.cdc.gov/abcs/reports-findings/survreports/gbs07.pdf (Accessed on March 21, 2012).
82. Schrag SJ, Farley MM, Petit S, et al. Epidemiology of Invasive Early-Onset Neonatal Sepsis, 2005 to 2014. Pediatrics 2016; 138.
83. https://www.cdc.gov/groupbstrep/clinicians/index.html.
84. Didier C, Streicher MP, Chognot D, et al. Late-onset neonatal infections: incidences and pathogens in the era of antenatal antibiotics. Eur J Pediatr 2012; 171:681.
85. Stoll BJ, Hansen NI, Sánchez PJ, et al. Early onset neonatal sepsis: the burden of group B Streptococcal and E. coli disease continues. Pediatrics 2011; 127:817.
86. Verani JR, Spina NL, Lynfield R, et al. Early-onset group B streptococcal disease in the United States: potential for further reduction. Obstet Gynecol 2014; 123:828.
87. Puopolo KM, Madoff LC, Eichenwald EC. Early-onset group B streptococcal disease in the era of maternal screening. Pediatrics 2005; 115:1240.

88. Van Dyke MK, Phares CR, Lynfield R, et al. Evaluation of universal antenatal screening for group B streptococcus. N Engl J Med 2009; 360:2626.
89. Lin FY, Weisman LE, Azimi P, et al. Assessment of intrapartum antibiotic prophylaxis for the prevention of early-onset group B Streptococcal disease. Pediatr Infect Dis J 2011; 30:759.
90. Sutkin G, Krohn MA, Heine RP, Sweet RL. Antibiotic prophylaxis and non-group B streptococcal neonatal sepsis. Obstet Gynecol 2005; 105:581.
91. Chen KT, Puopolo KM, Eichenwald EC, et al. No increase in rates of early-onset neonatal sepsis by antibiotic-resistant group B Streptococcus in the era of intrapartum antibiotic prophylaxis. Am J Obstet Gynecol 2005; 192:1167.
92. Towers CV, Carr MH, Padilla G, Asrat T. Potential consequences of widespread antepartal use of ampicillin. Am J Obstet Gynecol 1998; 179:879.
93. Towers CV, Briggs GG. Antepartum use of antibiotics and early-onset neonatal sepsis: the next 4 years. Am J Obstet Gynecol 2002; 187:495.
94. Mercer BM, Carr TL, Beazley DD, et al. Antibiotic use in pregnancy and drug-resistant infant sepsis. Am J Obstet Gynecol 1999; 181:816.
95. Glasgow TS, Young PC, Wallin J, et al. Association of intrapartum antibiotic exposure and late-onset serious bacterial infections in infants. Pediatrics 2005; 116:696.
96. Rentz AC, Samore MH, Stoddard GJ, et al. Risk factors associated with ampicillin-resistant infection in newborns in the era of group B streptococcal prophylaxis. Arch Pediatr Adolesc Med 2004; 158:556.
97. Sinha A, Yokoe D, Platt R. Intrapartum antibiotics and neonatal invasive infections caused by organisms other than group B streptococcus. J Pediatr 2003; 142:492.
98. Schrag SJ, Hadler JL, Arnold KE, et al. Risk factors for invasive, early-onset Escherichia coli infections in the era of widespread intrapartum antibiotic use. Pediatrics 2006; 118:570.
99. Puopolo KM, Eichenwald EC. No change in the incidence of ampicillin-resistant, neonatal, early-onset sepsis over 18 years. Pediatrics 2010; 125:e1031.
100. Phares CR, Lynfield R, Farley MM, et al. Epidemiology of invasive group B streptococcal disease in the United States, 1999-2005. JAMA 2008; 299:2056.
101. Castor ML, Whitney CG, Como-Sabetti K, et al. Antibiotic resistance patterns in invasive group B streptococcal isolates. Infect Dis Obstet Gynecol 2008; 2008:727505.
102. Bizzarro MJ, Dembry LM, Baltimore RS, Gallagher PG. Changing patterns in neonatal Escherichia coli sepsis and ampicillin resistance in the era of intrapartum antibiotic prophylaxis. Pediatrics 2008; 121:689.
103. Ecker KL, Donohue PK, Kim KS, et al. The impact of group B streptococcus prophylaxis on late-onset neonatal infections. J Perinatol 2013; 33:206.

104. Siegel JD, McCracken GH Jr, Threlkeld N, et al. Single-dose penicillin prophylaxis of neonatal group-B-streptococcal disease. Lancet 1982; 1:1426.
105. Patel DM, Rhodes PG, LeBlanc MH, et al. Role of postnatal penicillin prophylaxis in prevention of neonatal group B streptococcus infection. Acta Paediatr 1999; 88:874.
106. Pyati SP, Pildes RS, Jacobs NM, et al. Penicillin in infants weighing two kilograms or less with early-onset Group B streptococcal disease. N Engl J Med 1983; 308:1383.
107. Woodgate P, Flenady V, Steer P. Intramuscular penicillin for the prevention of early onset group B streptococcal infection in newborn infants. Cochrane Database Syst Rev 2004; :CD003667.

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Contributor Disclosures

Carol J Baker, MD Consultant/Advisory Boards: Pfizer [Group B Streptococcus and Streptococcus pneumoniae vaccines].**Vincenzo Berghella, MD**Consultant/Advisory Boards: ProtocolNow [Clinical guidelines].**Daniel J Sexton, MD**Grant/Research/Clinical Trial Support: Centers for Disease Control and Prevention; National Institutes of Health [Healthcare epidemiology]. Consultant/Advisory Boards: Magnolia Medical Technologies [Medical diagnostics]; Johnson & Johnson [Mesh-related infections]. Equity Ownership/Stock Options: Magnolia Medical Technologies [Medical diagnostics].**Vanessa A Barss, MD, FACOG**Nothing to disclose

Contributor disclosures are reviewed for conflicts of interest by the editorial group. When found, these are addressed by vetting through a multi-level review process, and through requirements for references to be provided to support the content. Appropriately referenced content is required of all authors and must conform to UpToDate standards of evidence.