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Assessment of Intrapartum Antibiotic Prophylaxis for the Prevention of Early-onset Group B Streptococcal Disease

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Abstract

Background—Most early-onset group B streptococcal (GBS) disease in recent years has occurred in newborns of prenatally GBS-negative mothers who missed intrapartum antibiotic prophylaxis (IAP). We aimed to assess the accuracy of prenatal culture in predicting GBS carriage during labor, the IAP use and occurrence of early-onset GBS disease.

Methods—We obtained vaginal-rectal swabs at labor for GBS culture from 5497 women of ≥ 32 weeks gestation and surface cultures at birth from newborns during 2/5/08–2/4/09 at three hospitals in Houston Texas and Oakland California. Prenatal cultures were performed by health care provider during routine care, and culture results obtained from medical records. The accuracy of prenatal culture in predicting intrapartum GBS carriage was assessed by positive (PPV) and negative (NPV) predictive values. Mother-to-newborn transmission of GBS was assessed. Newborns were monitored for early-onset GBS disease.

Results—GBS carriage was 24.5% by prenatal and 18.8% by labor cultures. Comparing prenatal with labor GBS cultures of 4696 women, the PPV was 50.5% and NPV 91.7%. IAP, administered to 93.3% of prenatally GBS-positive women, was 83.7% effective in preventing newborn's GBS colonization. Mother-to-newborn transmission of GBS occurred in 2.6% of elective Cesarean deliveries. Two newborns developed early-onset GBS disease (0.36/1000 births): one's prenatal GBS culture was negative, the other's unknown.

Conclusions—IAP was effective in interrupting mother-to-newborn transmission of GBS. However, ~10% of prenatally GBS-negative women were positive during labor and missed IAP while ~50% of prenatally GBS-positive women were negative during labor and received IAP. These findings emphasize the need for rapid diagnostics during labor.

Keywords

group B streptococcus; early onset disease; predictive values; prenatal cultures; intrapartum antibiotic prophylaxis

INTRODUCTION

Intrapartum antibiotic prophylaxis (IAP) has been the strategy of the U.S. National Guidelines for prevention of perinatal group B streptococcal (GBS) disease [1–2]. The widespread use of IAP in the U.S has been accompanied by a reduction of neonatal early-onset GBS disease from 1.8/1,000 live births in the early 1990's to 0.35 in 2003 [3] and has remained at this level since [4]. The revised guidelines of 2002 and 2010 recommend universal screening of GBS at 35–37 weeks gestation and IAP to women who have had a positive prenatal GBS culture, had GBS bacteriuria during the current pregnancy, had an infant with invasive GBS disease previously, or whose GBS status is unknown and has any of the following clinical features: preterm delivery (<37 weeks gestation), ruptured membranes ≥ 18 hours or fever ($>38.0^{\circ}\text{C}$) during labor. IAP, however, is not recommended for prenatally GBS-positive women who undergo Cesarean delivery without labor or ruptured membranes [2, 5]. These recommendations have been widely implemented in the U.S. A survey in 2003–4 of selected counties in 10 states in the U.S. reported that 85.0% of women were screened for GBS before delivery and 85.1% of women who were eligible for antibiotic treatment during labor received chemoprophylaxis [6].

These guidelines, however, have limitations because prenatal cultures do not accurately predict GBS carriage during labor. Prior studies have reported that 4.0 to 11.6% of prenatally GBS-negative women had positive GBS cultures during labor [7–13] whereas 13.0 to 54.7% of prenatally GBS-positive women had a negative culture during labor (Table 1) [7–15]. Thus, some women who are colonized during labor will not receive IAP subjecting their newborns to the risk of early-onset GBS disease. Those who are colonized prenatally but cultured negative during labor are given IAP despite a low risk of delivering infants with early-onset GBS disease. Recent studies have reported that 61–82% of term newborns with early-onset GBS disease were born to prenatally GBS-negative mothers [6, 16–17]. In this study we not only compared routine prenatal GBS culture with those cultures obtained during labor in a large population, but also assessed intrapartum antibiotic administration and mother-to-newborn transmission of GBS and evaluated these findings related to the prevention of early-onset GBS disease.

METHODS

We analyzed data obtained from a prospective study whose primary aim was to assess the relation of neonatal respiratory distress and maternal GBS carriage during labor. The study enrolled a cohort of pregnant women and their newborns during the period of 2/5/2008 to 2/4/2009 from three hospitals in Houston Texas and Oakland California. Using the same protocol, women of ≥ 32 weeks gestation were cultured on admission for delivery and their newborns at birth for GBS carriage. Prenatal cultures were performed by their health care providers during routine care.

The Institutional Review Board of Baylor College of Medicine, Children's Hospital & Research Center Oakland, Alta Bates Summit Medical Center and the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, National Institutes of Health reviewed and approved the study. Maternal consent was obtained during prenatal visits or after admission for delivery.

Study Design

Ben Taub General Hospital and St. Luke Episcopal Hospital affiliated with Baylor College of Medicine, Houston Texas and Alta Bates Summit Medical Center with the Children's Hospital and Research Center Oakland participated in enrolling mothers on admission for delivery and providing initial care for newborns. Newborns requiring Level II/III nursery

care received it at their birth hospital or were transferred to Texas Children's Hospital or to Children's Hospital & Research Center Oakland.

Vaginal and rectal swabs for GBS culture were obtained daily by physicians, obstetric or study nurses during all shifts from women ≥ 32 weeks gestation on admission for delivery ("the labor culture") according to recommended procedures [2]. Women were designated as GBS ++ (prenatal/labor), GBS +/-, GBS -/+ or GBS -/- according to their prenatal and labor culture results.

Newborns had cultures taken from the throat, anus, umbilicus and both external ear canals before their first bath [18]. The nursing and study staff followed the newborns for the duration of the hospital stay. Prenatal culture results, demographic data and antibiotic use during labor were obtained from the medical records.

Microbiological Procedures

Polyurethane-tipped swabs in transport media (BBL Culture Swab EZ/EZ11 Collection and Transport System) were used to obtain cultures from mothers' vaginal and rectal areas and newborns' surface sites. Standard microbiologic techniques were used to identify GBS. β -hemolytic colonies and suspicious non-hemolytic colonies were tested for GBS by latex agglutination (PathoDx, Diagnostic Products Corporation). Isolation and identification of GBS were performed at a designated microbiology laboratory at each study site using the same protocol.

Semi quantitative culture of maternal vaginal-rectal swab

Vaginal-rectal swabs were refrigerated and processed within 72 hours by placing in 2mL Todd-Hewitt Broth (THB) containing polymyxin B (10 $\mu\text{g/mL}$), nalidixic acid (15 $\mu\text{g/mL}$) and crystal violet (0.1 $\mu\text{g/mL}$) and vortexed. A 0.01 mL aliquot of the broth was removed using a calibrated loop, streaked onto a colistin-nalidixic acid (CNA) agar plate similar to the way urine culture is performed and incubated at 37°C for 18–24 hours. The GBS colonies were then counted and recorded as 0, 1–50 colonies ($<10,000$ CFU/swab), 51–100 colonies (10,000–20,000 CFU/swab), >100 colonies ($>20,000$ CFU/swab) [19]. If no GBS colonies were found on the CNA plate, the original broth (which had been incubated overnight) was sub-cultured onto a 5% sheep blood agar plate. Since the organisms multiply in the broth during incubation, the subcultured plate could only be interpreted as positive or negative. For analyses, the density of growth was defined as follows: Grade I if no GBS colonies were found on the CNA plate but the broth subculture was positive, Grade II when 1–50 colonies of GBS were counted on the CNA plate, Grade III, 51–100 colonies, and Grade IV when >100 colonies were counted.

Newborn culture

The swabs were refrigerated and processed within 72 hours by placing each swab into Todd-Hewitt broth containing antibiotics as described above and incubated for 18–24 hours. The broth was then subcultured on sheep-blood agar plates at 37°C for 24–48 h. β -hemolytic colonies and suspicious non-hemolytic colonies were tested for GBS

Statistical analyses

The accuracy of prenatal culture in predicting intrapartum GBS carriage was assessed by positive (PPV) and negative (NPV) predictive values. PPV was determined by calculating $(\text{number of GBS ++ women}) \div (\text{number of GBS ++ and GBS +/- women}) \times 100\%$, and NPV by $(\text{number of GBS -/- women}) \div (\text{number of GBS -/- and GBS -/+ women}) \times 100\%$. The efficacy of IAP in interrupting mother-to-newborn transmission was calculated by $(1 - \text{transmission rate in treated mother} \div \text{transmission rate in untreated mothers}) \times 100\%$.

Confidence intervals for the efficacy of IAP were obtained by transforming the asymptotic confidence intervals for the relative risk. Fisher's exact test was used for the comparisons of proportions. Confidence intervals for proportions were based on the exact formula for the binomial distribution.

RESULTS

Vaginal-rectal cultures were obtained from 5497 women on admission for delivery (2688 in Houston and 2809 in Oakland) among 15,461 deliveries (7797 in Houston and 7664 in Oakland). The cohort was racially and ethnically diverse and not different from those of the total maternal population of the study sites. Mothers' ages ranged from 15 to 47 years (median: 29.3 years). Overall, 27.3% of the women were primi gravidas and 25.6% had Cesarean deliveries, of which 25% were elective. Multiple births occurred in 1.2%. The newborns' birth weights ranged from 1060 to 5456 grams with a median of 3359 grams, and 93.5% of newborns were full term (≥ 37 weeks' gestation) (see Supplemental Digital Content 1 which describes the characteristics of mothers and their newborns).

Prenatal culture

Among the women in the cohort, 4778 (86.9%) had prenatal cultures; results were available in 4696 (98.3%); 1172 (24.5%) of them were positive. Prenatal cultures were positive in 30.2% of women in Oakland compared to 18.5% in Houston ($P < 0.001$). The timing of prenatal cultures was not available for 1535 (32.1%) women (1117 in Oakland and 418 in Houston). For those whose gestational age at the prenatal cultures were recorded ($n = 3243$, 67.9%), 12.5% were at < 35 weeks gestation, 75.7% at 35–37 weeks, and 11.8% at ≥ 38 weeks. Of women who had prenatal cultures at < 35 weeks, 72% delivered at term.

Labor culture

Of women cultured during labor, 1031 (18.8%) were positive for GBS (19.0% in Houston and 18.4% in Oakland). The carriage rate of Black women (27.9%) was higher than of White (17.7%), Hispanic (17.5%) or Asian women (13.6%) ($P < 0.001$). Among colonized women, 46.6% had Grade I, 29.7% had Grade II, 15.6% had Grade III and 8.2% had Grade IV growth density. The proportion of women who had heavy carriage of GBS (Grade II – IV growth density) was higher among the GBS $+/+$ than the GBS $-/+$ women (60.0% vs. 43.6%, $P < 0.001$).

Discordance of GBS carriage between the prenatal and labor periods

Of the 1172 prenatally GBS-positive women, 592 (50.5%) had positive, and 580 (49.5%) had negative cultures during labor. The PPV of prenatal culture for GBS carriage during labor was 50.5% (95% CI: 47.6 – 53.4%); higher in Houston than in Oakland (62.8% vs. 43.5%, $P < 0.001$) (Table 2). Among the 3524 prenatally GBS-negative women, 91.7% had negative and 8.3% had positive culture during labor. The NPV was 91.7%, similar at the two study sites. The PPV was highest for women whose cultures were taken within one week of delivery and lowest among those whose cultures were taken at ≥ 6 weeks of delivery (69.7% vs. 54.4%, $P = 0.03$). For women whose prenatal cultures were taken at 35–37 weeks gestation as recommended, the PPV was 60.6% and the NPV 89.5%. The PPV was significantly lower in women with unknown timing of prenatal culture than those with a known timing (28.7% vs. 61.1%, $P < 0.001$). The proportion of women who received antibiotics during pregnancy was not statistically different between the GBS $+/-$ and the GBS $+/+$ women (18.6% vs. 15.2%, $P = 0.29$).

Antibiotic administration during labor

Overall, 38.3% of mothers received antibiotics during labor (45.7% in Oakland and 30.4% in Houston, $P<0.001$). Of the prenatally GBS-positive women, 93.3% received IAP, similar for GBS $+/+$ and GBS $+/-$ mothers (93.8% vs. 92.9%). Of the prenatally GBS-negative women, 20.0% received antibiotics for reasons such as suspected maternal infection, Cesarean delivery, preterm labor or prolonged ruptured membranes. The proportion of women who received antibiotics was similar for GBS $-/+$ and GBS $-/-$ mothers (21.6% vs. 19.9%).

For women who received IAP, 35.5% had the first dose at ≤ 2 hours, 10.1% at 2–3.9 hours and 54.4% at ≥ 4 hours prior to delivery. β -lactam antibiotics were used in 94% of women who received IAP. One woman (0.2/1000 deliveries) experienced an itchy throat, difficulty in breathing and swollen lips after receiving ampicillin for GBS in the prenatal culture.

Mother-to-newborn transmission of GBS

Mother-to-newborn transmission of GBS was determined by isolation of GBS from at least one of the four surface sites of the neonate born to a labor GBS-positive mother. Mother-to-newborn transmission rate was 16.1% for all deliveries: higher among newborns of mothers who did not receive antibiotics (untreated) than of those who received antibiotics during labor (treated) (38.2% vs. 6.3%, $P<0.001$). Overall, IAP was 83.7% (95% CI: 77.6–88.1%) effective in interrupting the mother-to-newborn transmission of GBS (Table 3).

For untreated mothers, the mother-to-newborn transmission rate was four-fold higher for vaginal than for Cesarean deliveries (45.1% vs. 10.9%, $P<0.001$) and tenfold higher for non-elective than for elective Cesarean deliveries (25.0% vs. 2.5%, $P=0.009$) (Table 3). Transmission was highest in women who had Grade IV (68.4%), intermediate in those who had Grade II (40.2%) or Grade III (38.9%) and lowest in those who had Grade I (33.7%) growth density ($P=0.02$). In treated mothers, the transmission rate varied from 6.6% in those who had Grade I growth density to 9.4% in those with Grade IV ($P=0.56$).

GBS transmission occurred in 3 of 116 (2.6%) labor GBS-positive women who underwent elective Cesarean deliveries, two received antibiotics; one did not (Table 3). The 3 colonized newborns (2 full terms, one 36 weeks gestation) were born to mothers who were not in labor and without ruptured membranes who received no intrapartum procedures other than epidural anesthesia. All 3 mothers were GBS $+/+$. The first had grade III growth density in the labor GBS culture, received no antibiotics during labor and her newborn had GBS grown from all 4 surface sites (heavily colonized) [18]. The second had grade IV growth, received one dose of cefazolin intravenously 2 hours before delivery and her newborn had GBS identified from all 4 surface sites (heavily colonized). The third who received cefazolin shortly before delivery, had Grade I growth and her newborn's GBS grew only from the external ear canals (lightly colonized) [18].

Early-onset GBS Sepsis

Early-onset GBS disease occurred in two newborns, one at Houston and one at Oakland; an incidence of 0.36/1000 live births. Both newborns had GBS isolated from blood cultures. Both were full term infants of mothers who delivered vaginally, had no fever or prolonged rupture of membranes. Neither of the mothers received antibiotics during labor.

The mother of the first case-patient had a negative prenatal culture at 35 weeks gestation, yet her culture during labor had Grade II growth of GBS and her newborn had GBS identified from all 4 surface sites. Her newborn developed respiratory distress three hours after birth, required supplemental oxygen and was admitted to the intensive care nursery. Spinal fluid

showed a white blood cell count of 91 WBC/mL and a positive GBS antigen test. The mother of the second case-patient had no documented prenatal GBS culture; her urine culture during the first trimester was negative for GBS. Neither the mother nor the newborn were swabbed for culture during labor and delivery. The newborn developed respiratory distress 11 hours after birth, required supplemental oxygen and was admitted to the intensive care nursery. The spinal fluid had white blood cell counts of 27 WBC/mL, showed no growth in culture and was negative for GBS antigen. Both newborns received two weeks of antibiotic treatment and were discharged home.

DISCUSSION

Similar to reports from elsewhere in the U.S. [6, 20–21] IAP was widely used to prevent perinatal GBS disease in the three participating hospitals of this study and was highly effective in interrupting the mother-to-newborn transmission of GBS. None of the newborns of prenatally GBS-positive mothers in this study developed early-onset GBS disease. However, two cases of early-onset GBS disease (0.36/1000 live births) occurred in full term newborns of mothers who had either negative prenatal culture or an unknown history of prenatal GBS culture. These data reaffirm the effectiveness of intrapartum antibiotic prophylaxis in preventing early-onset GBS disease and are consistent with the observations that the majority of recent cases of early-onset GBS disease occurred in newborns of prenatally GBS-negative mothers [6, 16–17].

In this study we compared GBS prenatal cultures from the nearly 5,000 women to their vaginal-rectal cultures at labor and demonstrated a 50.5% PPV and 91.7% NPV (Table 2). Our findings are consistent with published reports which showed that both positive and negative predictive values of prenatal culture for GBS carriage during labor are not optimal (Table 1). These findings revealed limitations of prenatal culture-based IAP. First, nearly 10% of prenatally GBS-negative mothers who were positive during labor would have missed IAP, resulting in the occurrence of early-onset GBS disease. Second, one third to ~50% of prenatally positive mothers would have received IAP despite negative labor cultures and low risk of delivering infants with early-onset GBS disease.

The current recommendation of not administering antibiotics to GBS-positive women who undergo elective Caesarean delivery was based on the lack of early-onset GBS disease in a retrospective study in a single hospital [22] and a review of CDC surveillance data of early-onset GBS disease as evidence for low risk of transmission [2]. These studies did not address the transmission of GBS from mother to newborn. A recent study in Sweden reported that none of 29 GBS-positive women who underwent elective Cesarean section transmitted GBS to their newborns [23]. Our data however showed that the transmission of GBS did occur in three of the 116 GBS colonized mothers who underwent elective Cesarean delivery, especially in heavily colonized women. Since newborn swabs were taken at birth before their first bath, it is unlikely that they acquired GBS after delivery. Colonized newborns are at risk of developing early-onset GBS disease with an attack rate of 1.2% [24]. Our observations warrant further studies on the transmission of GBS among elective Cesarean deliveries.

The cohort in this study was racially and ethnically diverse. When race-adjusted to the entire U.S. population our data estimates that for 4.2 million births annually and a Cesarean section rate of 32% [25]: (1) 772 cases early-onset GBS disease could occur in newborns of GBS –/+ mothers, an incidence of 0.18/1000 live births; (2) relying on prenatal cultures could result in overtreatment with IAP to about 310,000 parturient women; and (3) without IAP, the mother-to-newborn transmission of GBS in mothers who undergo elective Cesarean delivery without labor or rupture of membrane to newborns could result in 14 cases of early-onset

GBS disease nationwide [See Supplemental Digital Content 2 which shows the estimates of (1) the annual incidence of early-onset GBS disease in newborns of prenatally GBS-negative mothers, and in those of prenatally GBS-positive women who undergo elective Caesarean deliveries; and (2) the number of prenatally GBS-positive women who receive IAP despite being culture-negative during labor].

The change of GBS carriage state between the prenatal and labor period in this study could not be explained by the antibiotic use during pregnancy because the proportion of women who received antibiotics during pregnancy was not different between the GBS +/- and GBS +/+ women. Longitudinal studies of GBS carriage have demonstrated that about half of pregnant women remained GBS-negative during gestation; of the remaining women who tested positive, 16%- 60% showed continuous positivity [7, 26].

The PPV differed between the study sites (62.8% in Houston vs. 43.5% in Oakland, $P<0.001$). The GBS cultures during labor were performed using a single protocol and the positive rates in these sites were similar (19.0% in Houston vs. 18.4% in Oakland, $P=0.49$). Their prenatal cultures positive rates, however, differed significantly (18.5% in Houston vs. 30.2% in Oakland, $P<0.001$). Prenatal cultures were performed by various providers and processed at different microbiology laboratories and the results of the prenatal cultures were then transcribed to medical records. The lower PPV in Oakland than in Houston remains unexplained. We found that the PPV was lower in women with unknown timing of prenatal cultures than that in those with known timing (29 vs. 61%, $P<0.001$). This might explain the lower PPV in Oakland because a large proportion of women in Oakland had unknown timing of their prenatal cultures. Additionally, the low PPV in those with unknown timing suggest that the timing of prenatal cultures may serve as a quality indicator for a screening program.

The discordance of GBS carriage between the prenatal and labor periods emphasizes the need for a reliable and prompt identification of GBS carriers at delivery to guide the administration of IAP. Most efforts have focused on the development of GBS-specific DNA-based real-time PCR assays. The use of PCR for intrapartum identification of GBS has advantages and limitations [27–32]. Despite its availability, the use of such tests in intrapartum settings is limited [5]. Active immunization of mothers with a GBS vaccine rather than antibiotic treatment would be the logical choice for future perinatal GBS disease prevention.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

- Centers for Disease Control and Prevention. Prevention of perinatal group B streptococcal disease. MMWR Morb Mortal Wkly Rep. 1996; 45(RR-7):1–24. [PubMed: 8531914]
- Centers for Disease Control and Prevention. Prevention of perinatal group b streptococcal disease. Revised guidelines from CDC. MMWR Morb Mortal Wkly Rep. 2002; 51(RR-11):1–24.
- Centers for Disease Control and Prevention. Rate of early-onset and late-onset invasive group B streptococcal disease in infants, by year, 1996–2004, Active Bacterial Core Surveillance system, United States. MMWR Morb Mortal Wkly Rep. 2005; 54(47):1205–08. [PubMed: 16319814]
- Centers for Disease Control and Prevention. Trends in perinatal group B streptococcal disease – United States, 2000–2006. MMWR Morb Mortal Wkly Rep. 2009; 58(05):109–112. [PubMed: 19214159]
- Centers for Disease Control and Prevention. Prevention of perinatal group B streptococcal disease. MMWR Morb Mortal Wkly Rep. 2010; 59(RR-10):1–32. [PubMed: 20075837]
- Van Dyke MK, Phares CR, Lynfield R, et al. Evaluation of universal antenatal screening for group B streptococcus. N Engl J Med. 2009; 360(25):2626–36. [PubMed: 19535801]
- Allardice JG, Baskett TF, Seshia MM, Bowman N, Malazdrewicz R. Perinatal group B streptococcal colonization and infection. Am J Obstet Gynecol. 1982; 142(6 Pt 1):617–20. [PubMed: 7039316]
- Boyer KM, Gadzala CA, Kelly PD, Burd LI, Gotoff SP. Selective intrapartum chemoprophylaxis of neonatal group B streptococcal early-onset disease. II. Predictive value of prenatal cultures. J Infect Dis. 1983; 148(5):802–9. [PubMed: 6355317]
- Yancey MK, Schuchat A, Brown LK, Ventura VL, Markenson GR. The accuracy of late antenatal screening cultures in predicting genital group B streptococcal colonization at delivery. Obstet Gynecol. 1996; 88(5):811–5. [PubMed: 8885919]
- Goodman JR, Berg RL, Gribble RK, Meier PR, Fee SC, Mitchell PD. Longitudinal study of group B streptococcus carriage in pregnancy. Infect Dis Obstet Gynecol. 1997; 5(3):237–43. [PubMed: 18476144]
- Edwards RK, Clark P, Duff P. Intrapartum antibiotic prophylaxis 2: positive predictive value of antenatal group B streptococci cultures and antibiotic susceptibility of clinical isolates. Obstet Gynecol. 2002; 100(3):540–4. [PubMed: 12220775]
- Hiller JE, McDonald HM, Darbyshire P, Crowther CA. Antenatal screening for Group B Streptococcus: a diagnostic cohort study. BMC Pregnancy Childbirth. 2005; 5:12. [PubMed: 16042773]
- Towers CV, Rumney RNC, Asrat T, Preslicka C, Ghamsary MG, Nageotte MP. The accuracy of late third-trimester antenatal screening for group B streptococcus in predicting colonization at delivery. Am J Perinatol. 2010; 27(10):789–90.
- Valkenburg-van den Berg AW, Sprij AJ, Oostvogel PM, et al. Prevalence of colonisation with group B Streptococci in pregnant women of a multi-ethnic population in The Netherlands. Eur J Obstet Gynecol Reprod Biol. 2006; 124(2):178–83. [PubMed: 16026920]
- El Helali N, Nguyen JC, Ly A, Giovannrandi Y, Trinquart L. Diagnostic accuracy of a rapid real-time polymerase chain reaction assay for universal intrapartum group B streptococcus screening. Clin Infect Dis. 2009; 49:417–23. [PubMed: 19580414]
- Puopolo KM, Madoff LC, Eichenwald EC. Early-onset group B streptococcal disease in the era of maternal screening. Pediatrics. 2005; 115(5):1240–6. [PubMed: 15867030]
- Pulver LS, Hopfenbeck MM, Young PC, Stoddard GJ, Korgenski K, Daly J, Byington CL. Continued early onset group B streptococcal infections in the era of intrapartum prophylaxis. J Perinatol. 2009; 29(1):20–5. [PubMed: 18704032]

18. Lin FY, Philips JB 3rd, Azimi PH, et al. Level of maternal antibody required to protect neonates against early-onset disease caused by group B Streptococcus type Ia: a multicenter, seroepidemiology study. *J Infect Dis.* 2001; 184(8):1022–8. [PubMed: 11574917]
19. Kontnick CM, Edberg SC. Direct detection of group B streptococci from vaginal specimens compared with quantitative culture. *J Clin Microbiol.* 1990; 28:336–339. [PubMed: 2179263]
20. Centers for Disease Control and Prevention. Adoption of perinatal group B streptococcal prevention recommendations by prenatal care providers – Connecticut and Minnesota, 1998. *MMWR Morb Mortal Wkly Rep.* 2000; 49:228–232. [PubMed: 10763673]
21. Watt JP, Schuchat A, Erickson K, Honig JE, Gibbs R, Schulkin J. Group B streptococcal disease prevention practices of obstetrician-gynecologists. *Obstet Gynecol.* 2001; 98(1):7–13. [PubMed: 11430949]
22. Ramus RM, McIntire DD, Wendel GD Jr. Antibiotic chemoprophylaxis for group B strep is not necessary with elective cesarean section at term {abstract}. *Obstet Gynecol.* 1999; 180:S85.
23. Håkansson S, Axemo P, Bremme K, et al. Swedish Working Group. For The Prevention of Perinatal Group B Streptococcal Infections. Group B streptococcal carriage in Sweden: a national study on risk factors for mother and infant colonisation. *Acta Obstet Gynecol Scand.* 2008; 87(1): 50–8. [PubMed: 18158627]
24. Lin FY, Troendle JF. Hypothesis: Neonatal respiratory distress may be related to asymptomatic colonization with group B streptococci. *Pediatr Infect dis J.* 2006; 25:884–888. [PubMed: 17006281]
25. Hamilton BE, Martin JA, Ventura SJ. Births: Preliminary data for 2008. *National Vital Statistics Reports.* April 6, 2010 58(16)
26. Hansen SM, Uldbjerg N, Kilian M, Sørensen UB. Dynamics of Streptococcus agalactiae colonization in women during and after pregnancy and in their infants. *J Clin Microbiol.* 2004; 42(1):83–9. [PubMed: 14715736]
27. Honest H, Sharma S, Khan KS. Rapid tests for group B Streptococcus colonization in laboring women: a systematic review. *Pediatrics.* 2006; 117(4):1055–66. [PubMed: 16585299]
28. Chan KL, Levi K, Towner KJ, Weston VC, Ramsay MM, Kean LH. Evaluation of the sensitivity of a rapid polymerase chain reaction for detection of group B streptococcus. *J Obstet Gynaecol.* 2006; 26(5):402–6. [PubMed: 16846863]
29. Aziz N, Baron EJ, D'Souza H, Nourbakhsh M, Druzin ML, Benitz WE. Comparison of rapid intrapartum screening methods for group B streptococcal vaginal colonization. *J Matern Fetal Neonatal Med.* 2005; 18(4):225–9. [PubMed: 16318971]
30. El Helali N, Nguyen JC, Ly A, Giovangrandi Y, Trinquart L. Diagnostic accuracy of a rapid real-time polymerase chain reaction assay for universal intrapartum group B streptococcus screening. *Clin Infect Dis.* 2009; 49(3):417–23. [PubMed: 19580414]
31. Money D, Dobson S, Cole L, et al. An evaluation of a rapid real time polymerase chain reaction assay for detection of group B streptococcus as part of a neonatal group B streptococcus prevention strategy. *J Obstet Gynaecol Can.* 2008; 30(9):770–5. [PubMed: 18845045]
32. Atkins KL, Atkinson RM, Shanks A, Parvin CA, Dunne WM, Gross G. Evaluation of polymerase chain reaction for group B streptococcus detection using an improved culture method. *Obstet Gynecol.* 2006; 108:488–91. [PubMed: 16946205]

Table 1
Published positive and negative predictive values of prenatal culture for Group B streptococcal carriage at labor

Study	Location	Gestational age at culture	Prenatal GBS + rate (%)	Number positive cultures		Positive predictive value (%)	Number negative cultures		Negative predictive value (%)
				Prenatal	At labor		Prenatal	at labor	
Allardice ⁷ 1982	Canada	28–34	10.3	53	29	(45.3)	471	452	(96.0)
Boyer ⁸ 1983	U.S.	1st–3rd trimester	22.8	393	264	(67.2)	200	183	(91.5)
Yancy ⁹ 1996	U.S.	35–36	26.5	193	168	(87.0)	633	607	(95.9)
Goodman ¹⁰ 1997	U.S.	26–28	13.9	111	67	(60.4)	706	675	(95.6)
Edwards ¹¹ 2002	U.S.	35–37	NA	218	146	(67.0)	NA	NA	NA
Hiller ¹² 2005	Australia	36	20.0	120	NA	(77.0)	480	NA	(94.0)
Valkenburg ¹⁴ 2006	Netherlands	35–37	21.0	173	136	(79.0)	588	530	(93.6)
El Helali ¹⁵ 2009	France	35–37	12.3	115	67	(58.3)	818	753	(92.1)
Towers ¹³ 2010	U.S.	Late 3 rd trimester	15.4	227	152	(67.0)	1245	1101	(88.4)
This study	U.S.	≥32	24.5	1172	592	(50.5)	3524	3233	(91.7)

Table 2
Discordance in group B streptococcus detection between the prenatal and the labor cultures

Study Site	Positive prenatal culture (N=1172)				Negative prenatal culture (N=3524)			
	Labor Culture				Labor culture			
	No. Cultured	No. Positive	Positive predictive value %, 95% CI		No. Cultured	No. Negative	Negative predictive value %, 95% CI	
Houston	425	267	62.8, 58.0 –67.4		1834	1680	91.6, 90.2 –92.8	
Oakland	747	325	43.5, 39.9 –47.2		1690	1553	91.9, 90.5 –93.2	
Total	1172	592	50.5, 47.6 –53.4		3524	3233	91.7, 90.8 –92.6	

Table 3

Mother-to-newborn transmission of group B streptococcus by antibiotic use during labor and by types of delivery

Antibiotic during labor	Type of delivery	Labor GBS-positive mothers (No.) [*]	GBS colonized newborns No. (% [*])
Yes	Vaginal	507	34 (6.7)
	C/S [†] -Non-elective	120	8 (6.7)
	C/S-Elective	76	2 (2.6)
	All types	703	44 (6.3) [‡]
No	Vaginal	253	114 (45.1) [§]
	C/S -Non-elective	24	6 (25.0) [§]
	C/S -Elective	40	1 (2.5) [§]
	All types	317	121 (38.2) [‡]
Total	All types	1020	165 (16.2)

^{*} Not included in the table are 21 mothers and their newborns due to missing data (newborns of 16 mothers were not swabbed and 5 mothers did not have data on antibiotic use)

[†] C/S: Cesarean section

[‡] Antibiotic use (treated) vs. no antibiotics (untreated): 6.3% vs. 38.21%; $P < 0.001$

[§] For untreated:

Vaginal delivery vs. non-elective C/S: 45.1% vs. 25.0%; $P < 0.001$

Vaginal delivery vs. elective C/S: 45.1% vs. 2.5%; $P < 0.001$

Non-elective vs. elective C/S: 25.0% vs. 2.5%; $P = 0.009$