OBSTETRICS

Differentiating *Streptococcus pseudoporcinus* from GBS: could this have implications in pregnancy?

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BACKGROUND: *Streptococcus agalactiae* (GBS) is a common pathogen known to cause neonatal and maternal infectious morbidity. *Streptococcus pseudoporcinus (S pseudoporcinus)* is a separate, recently identified β-hemolytic gram-positive coccus that can cause false-positive results on standard GBS agglutination testing assays.

OBJECTIVE: To determine the prevalence and clinical implications of *Streptococcus pseudoporcinus* colonization in pregnancy.

MATERIALS AND METHODS: This is a 2-year retrospective cohort study comparing pregnant women colonized with GBS to those colonized with *S. pseudoporcinus*. A proteomics method of identification, namely, matrix-assisted laser desorption ionization time-of-flight mass spectrometry, was used to distinguish between *S. pseudoporcinus* and GBS colonization. Antibiotic susceptibility testing was carried out on all specimens. Maternal and neonatal chart reviews were conducted to identify predictors of *S. pseudoporcinus* colonization and to compare maternal and neonatal outcomes.

RESULTS: *S. pseudoporcinus* colonization occurred in 1.6% of all pregnancies. A total of 2.5% of all GBS-positive results by agglutination assay were false positive, instead reflecting *S. pseudoporcinus* colonization. Clindamycin resistance among *S. pseudoporcinus* isolates is uncommon. *S. pseudoporcinus* colonization in pregnancy is independently associated with African American race, tobacco use, and body mass index ≥35. Preterm premature rupture of membranes or spontaneous preterm birth was more common in patients colonized with *S. pseudoporcinus.*

CONCLUSION: Although the prevalence of *S. pseudoporcinus* colonization is low, it primarily occurs in African American women and is associated with preterm premature rupture of membranes or spontaneous preterm birth when compared to individuals colonized with GBS.

Key words: GBS, GBS colonization in pregnancy, preterm birth, preterm premature rupture of membranes, *Streptococcus agalactiae*, *Streptococcus pseudoporcinus*

Streptococcus agalactiae (GBS) is a β-hemolytic gram-positive coccus that colonizes the gastrointestinal and genitourinary tract of 15−40% of pregnant women and is recognized as the leading cause of neonatal sepsis. The Centers for Disease Control and Prevention (CDC) recommend GBS rectovaginal cultures for all pregnant women at 35−37 weeks' gestation to identify those neonates at risk for GBS sepsis and to appropriately provide antibiotic prophylaxis.[1] The initiation of this antenatal screening protocol and the use of intrapartum antibiotic prophylaxis have reduced the incidence of neonatal sepsis by 80%.

Streptococcus pseudoporcinus (*S. pseudoporcinus*) is a recently identified β-hemolytic gram-positive coccus that became a separate and independent *Streptococcus* species in 2006.[2] *S. pseudoporcinus* has been isolated from the female genitourinary tract and has biochemical characteristics similar to those of GBS.[2−5] Initial epidemiologic studies focused on colonization in the nonpregnant population. In 2011, Stoner et al subsequently reported that 5.4% of nonpregnant women had genital cultures positive for *S. pseudoporcinus*, and that colonization was independently associated with African American race, reproductive age, recent concomitant genitourinary infection with *Trichomonas*, genital herpes, bacterial vaginosis, and multiple sexual partners.[6] Of clinical relevance was the fact that all 120 of the *S. pseudoporcinus* isolates cross-reacted with a commonly used, commercially available GBS serogrouping kit, raising concerns about possible treatment decisions in pregnant women based on the misidentification of this bacterium as GBS.

Advances in microbiological bacterial identification have allowed easier detection of *S. pseudoporcinus,* and we became aware of the possibility of *S. pseudoporcinus* misidentification from GBS screening cultures after implementation of matrix-assisted laser desorption ionization−time-of-flight mass spectrometry (MALDI-TOF MS) analysis at our institution. MALDI-TOF MS is becoming more routinely used for organism identification in clinical microbiology laboratories.[7−9] It is based on the principle of protein profile analysis after extraction of largely ribosomal proteins from cultured isolates and ionization of them with the assistance of a laser after matrix stabilization.[9] After an initial substantial capital expense (US $180,000), the cost of organism identification is about US $0.50.[9] Laboratories still using antigen testing kits may mistake *S. pseudoporcinus* for GBS. Misidentification of this bacteria as GBS could lead to the unnecessary use of antibiotics during pregnancy as well as increase the possibility of subsequent emergence of resistant bacteria. The prevalence and clinical significance of genitourinary *S. pseudoporcinus* and its relationship to peripartum neonatal and maternal outcomes is not well described. However, it is conceivable that colonization with this organism may have significant peripartum implications.

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AJOG at a Glance

Why was this study conducted?

To explore the prevalence of *Streptococcus pseudoporcinus (S pseudoporcinus)* colonization in pregnancy and its clinical implications on maternal and neonatal health.

Key findings

The overall prevalence of *S pseudoporcinus* is low (1.6%) but can cause false-positive *Streptococcus agalactiae* (GBS) results in pregnancy. *S pseudoporcinus* occurs primarily in African American women. Preterm premature rupture of membranes and spontaneous preterm birth were more common in patients colonized with *S pseudoporcinus* when compared to those with GBS.

What does this add to what is known?

Little is known about the implications of this recently identified bacterium in pregnancy, which can cause false-positive GBS results on routine screening. This study introduces its prevalence and potential clinical implications in pregnancy.

The aims of this study were to identify the prevalence of *S. pseudoporcinus* colonization among pregnant women and to identify maternal and perinatal morbidity associated with this bacterium. We hypothesized, based on prior studies of *S. pseudoporcinus* colonization in the nonpregnant population, that pregnant women colonized with *S. pseudoporcinus* would more likely be African American and to have concomitant genitourinary infections when compared to individuals with GBS. In addition, given some of the similar biochemical characteristics between GBS and *S. pseudoporcinus*, we also aimed to investigate whether women colonized with *S. pseudoporcinus* would have similar rates of peripartum morbidity when compared with their GBS-colonized counterparts.

Materials and Methods

This is a single-center, 2-year, retrospective cohort study approved by the Johns Hopkins School of Medicine Institutional Review Board, comparing pregnant women colonized with *S. pseudoporcinus* to those colonized with GBS. Between April 1, 2014, and March 31, 2016, urine and rectovaginal cultures were collected and used to identify colonization with *S. pseudoporcinus* and GBS antenatally. These specimens were obtained as part of routine urine and GBS antenatal screening, as well as for any other indication that arose throughout the pregnancy that warranted a rectovaginal or urine culture. Specimens were inoculated and cultured. β-Hemolytic colonies from GBS screening cultures were further identified as either GBS or *S. pseudoporcinus* using MALDI-TOF MS. If *S. pseudoporcinus* was identified, B antigen typing was then performed to determine the presence of the B antigen. Clindamycin susceptibility testing was performed on all *S. pseudoporcinus* and GBS isolates.

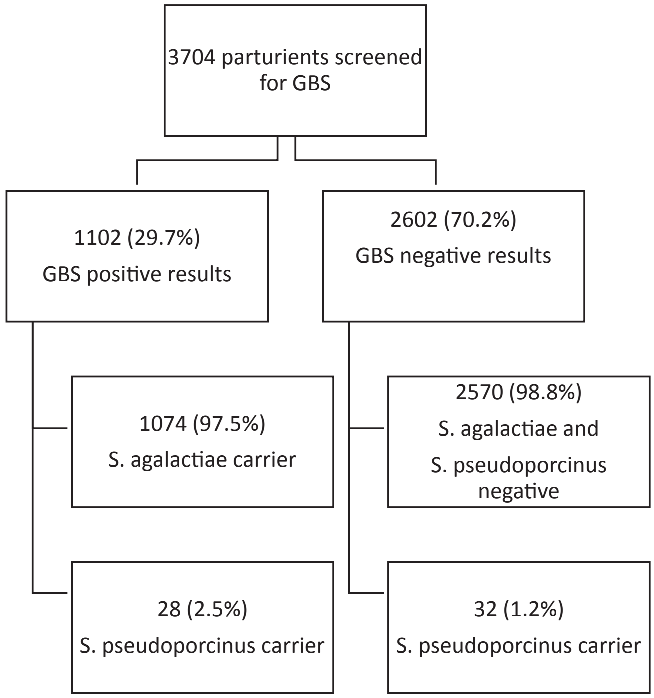
An extensive chart review was completed for all cases of *S. pseudoporcinus* colonization and a randomly selected cohort of 505 women colonized with GBS. Random selection for GBS colonized patients was performed through a Microsoft Excel (Microsoft Corp., Redmond, WA) randomization function of the entire patient population colonized with GBS during the period. Baseline characteristics, maternal medical comorbidities, antepartum and intrapartum clinical courses, and pregnancy outcomes were reviewed. Spontaneous preterm birth was defined as any spontaneous delivery before 37 weeks. Iatrogenic preterm deliveries that were not spontaneous in onset were excluded. Preterm premature rupture of membranes (PPROM) was defined as membrane rupture before the onset of labor and before 37 weeks' gestation. Maternal characteristics included factors determined by prior studies to be associated with *S. pseudoporcinus* colonization, as well as characteristics that have been shown to be associated with the outcome variables of interest, such as maternal age, body mass index (BMI), tobacco use, and diabetes. High maternal BMI is defined as a BMI $\geq$35, indicating patients with class II or III obesity. Diabetes is defined as any patient with a diagnosis of pregestational or gestational diabetes. Insurance status was used as a surrogate indicator of socioeconomic status. Current sexually transmitted infection (STI) or urinary tract infection (UTI) was defined as occurring during the pregnancy. A history of an STI or UTI reflected a self-reported prior infection outside of the pregnancy. Neonatal outcomes were also confirmed by review of all neonatal records.

The primary outcome was a composite of maternal morbidity, which included PPROM, spontaneous preterm birth, postpartum fever, postpartum endomyometritis, and postpartum wound infection. Endomyometritits was defined as a clinical diagnosis made by a clinician in the postpartum period warranting the initiation of antibiotics. Wound infection was similarly defined as a clinical or culture-proven diagnosis made by a clinician and warranting the initiation of antibiotics. Postpartum fever was defined as a temperature of at least 38°C before discharge from the hospital.

A secondary outcome was a composite of neonatal morbidity, which included admission to the neonatal intensive care unit (NICU), neonatal sepsis, and respiratory distress syndrome. Neonatal sepsis was defined by our institution's clinical criteria for presumed or culture-proven sepsis, thereby warranting the initiation of antibiotics. Neonates with respiratory distress syndrome were identified as those who received this diagnosis at some point during their hospitalization by a neonatologist.

To avoid any sources of bias in data collection, data were collected on the entire cohort of *S. pseudoporcinus* carriers and their neonates during the study period. For feasibility purposes, the records of a random sample of all GBS carriers were reviewed.

FIGURE 1
Results of parturients screened for *Streptococcus agalactiae* (GBS) during pregnancy



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Statistical analyses were performed using the χ^2 or Fisher exact test to analyze categorical variables and the Student *t* test for continuous variables. Odds ratios with 95% confidence intervals (CI) were calculated to determine predictors of *S. pseudoporcinus* colonization during pregnancy. Relative risks with 95% confidence intervals were calculated for outcome variables. Adjustments for characteristics that were not balanced in our cohorts were analyzed using logistic regression and generalized linear models. Stata version 14 (StataCorp LP, College Station, TX) was used for statistical analysis.

Results

A total of 3704 pregnant women were screened for GBS during the study period (Figure 1). Of these women, 1102 (29.7%) tested positive for a β-hemolytic *Streptococcus* with either rectovaginal or urine culture. Using MALDI-TOF MS, 60 cases were identified as *S. pseudoporcinus* and 1074 were confirmed as GBS. In all, 28 of the *S. pseudoporcinus* cases tested positive for the B antigen and were therefore reported as GBS positive in the medical record system. Consequently, 2.5% of all reported cases of GBS in the medical record were "false-positive" GBS results. Of the 60 *S. pseudoporcinus* carriers, 32 were negative for the B antigen and were reported as GBS negative in the medical record system. Confirmed cases of *S. pseudoporcinus* colonization represented 1.6% of all women screened for GBS. Confirmed cases of GBS represented 29% of all women screened. Clindamycin resistance was identified in 31% of GBS specimens, yet only in 5% of *S. pseudoporcinus* specimens ($P < .001$).

Characteristics of *S. pseudoporcinus* and GBS carriers in pregnancy are reported in Table 1. The 2 groups were similar in maternal age, yet differed by body mass index (BMI), race, smoking status, socioeconomic status, diabetic status, and history of an STI. Specifically, 59 of 60 women (98.6%) colonized with *S. pseudoporcinus* were African American, compared to 333 of 505 women (65.9%) colonized with GBS. Women colonized with *S. pseudoporcinus* were more likely to have a BMI ≥35, to use tobacco, to have diabetes, and to have a history of an STI. With regard to diabetes, the *S. pseudoporcinus* patients with diabetes were primarily those with gestational diabetes (78%), whereas 51% of the GBS carriers had gestational diabetes. Women with *S. pseudoporcinus* were more likely to have a history of gonorrhea infection ($P = .033$) or to have an HSV2 infection during the current pregnancy ($P = .003$). There were no statistically significant differences between the 2 groups with respect to UTIs or a concomitant STIs, other than HSV2, during pregnancy. More patients in the GBS group had private insurance, or were considered of higher socioeconomic status, compared to those in the *S. pseudoporcinus* group.

Because *S. pseudoporcinus* was predominantly identified in African Americans, a subgroup analysis was performed comparing only African American carriers of *S. pseudoporcinus* and GBS. In this subgroup, *S. pseudoporcinus* was still more common in patients with a BMI ≥35, those with diabetes, and those with a concomitant HSV2 infection during pregnancy. The subgroups were otherwise similar with respect to socioeconomic status, tobacco use, and presence or history of STIs/UTIs.

The 2 groups did differ significantly in some important characteristics of labor and delivery. There was a higher proportion of cesarean deliveries in the *S. pseudoporcinus* group when compared to the GBS group (45% vs 34.5%, $P = .001$). Also, although intrapartum antibiotics were administered to 96.8% of patients with GBS, only 63.3% ($P < .001$) of *S. pseudoporcinus* patients received intrapartum antibiotics.

Multivariate logistic regression was used to identify which differences in baseline characteristics might be predictors of *S. pseudoporcinus* colonization (Table 2). Tobacco use and BMI ≥35 were significant predictors of *S. pseudoporcinus* colonization.

TABLE 1
Characteristics of *S. pseudoporcinus* vs GBS carriers in pregnancy

	S. pseudoporcinus n = 60	GBS n = 505	*P* value
Maternal age, y (mean ± SD)	27.8 ± 5.3	27.2 ± 6.7	.539
BMI (mean ± SD)	37.2 ± 9.7	28.8 ± 8.3	<.001
BMI ≥35	37 (61.7%)	110 (21.8%)	<.001
Race			<.001
African American	59 (98.3%)	333 (65.9%)	
White	1 (1.6%)	126 (24.9%)	
Other	0 (0%)	46 (9.1%)	
Private insurance	12 (20%)	199 (39.4%)	.004
EGA at sample collection, wk (mean ± SD)	30.7 ± 9.1	32.8 ± 6.8	.042
Tobacco use	13 (21.6%)	59 (11.7%)	.014
Diabetes	9 (15.0%)	37 (7.3%)	.008
History of sexually transmitted infection	28 (46.6%)	168 (33.3%)	.013
Current sexually transmitted infection	14 (23.3%)	91 (18%)	.204
History of UTI	8 (13.3%)	104 (20.6%)	.287
Current UTI	13 (21.6%)	116 (22.9%)	.911

Data are mean ± SD or n (%).

BMI, body mass index; *EGA,* estimated gestational age; *GBS, Streptococcus agalactiae; S. pseudoporcinus, Streptococcus pseudoporcinus; SD,* standard deviation; *UTI,* urinary tract infection.

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The primary outcome, defined as a composite maternal morbidity, was observed in 25% of women colonized with *S. pseudoporcinus* and 15.6% of women colonized with GBS (Table 3). Women colonized with *S. pseudoporcinus* more frequently experienced PPROM or spontaneous preterm birth. There were no significant differences in rates of chorioamnionitis, postpartum fever, endomyometritis, or wound infections.

The secondary outcome, defined as composite neonatal morbidity, was more common in the *S. pseudoporcinus* cohort (26.6% vs 18.8%), although this difference did not meet statistical significance (P = .099). Neonates of *S. pseudoporcinus* carriers were more frequently admitted to the NICU. There were no significant differences in rates of neonatal sepsis or respiratory distress syndrome.

TABLE 2
Predictors of *S. pseudoporcinus* colonization during pregnancy

	Unadjusted OR (95% CI)	*P* value	Adjusted OR (95% CI)	*P* value
Tobacco use	2.28 (1.16–4.49)	.017	2.23 (1.06–4.72)	.035
Diabetes	1.54 (0.91–2.62)	.111	1.10 (0.63–1.92)	.731
Private insurance	0.39 (0.20–0.75)	.005	0.59 (0.42–2.25)	.120
BMI ≥35	5.78 (3.29–10.13)	<.001	5.02 (2.11–8.35)	<.001
History of STD	2.01 (1.15–3.49)	.014	1.14 (0.19–1.71)	.693

BMI, body mass index; *CI,* confidence interval; *OR,* odds ratio; *S. pseudoporcinus, Streptococcus pseudoporcinus; STD,* sexually transmitted disease.

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These primary and secondary outcomes were further assessed using a generalized linear model to estimate the relative risk of the outcome, while adjusting for potential confounding variables (Table 4). After adjusting for BMI, insurance status, smoking status, and STI history, *S. pseudoporcinus* remained associated with PPROM or preterm labor when compared to GBS. *S. pseudoporcinus* colonization was associated with a slightly higher risk of overall maternal morbidity when adjusted for BMI, mode of delivery, and intrapartum antibiotic use. When adjusting for spontaneous preterm birth, mode of delivery, and intrapartum antibiotic use, *S. pseudoporcinus* colonization appears to be associated with a slightly higher risk of NICU admission, yet this failed to reach statistical significance.

Maternal and neonatal outcomes were also evaluated in the subgroups of African American parturients with the 2 bacteria subtypes. Significant differences between the 2 groups persisted in this subanalysis, with higher rates in the *S. pseudoporcinus* group of composite maternal morbidity (25.4% vs 16.5%, P = .032), PPROM, or spontaneous preterm labor (16.9% vs 6%, P = .001), and NICU admission rates (27.1% vs 14.4%, P = .003).

A unique subgroup of patients are those colonized with *S. pseudoporcinus* who did not receive intrapartum antibiotics, either because their result was reported as GBS negative or because they had no other indication for antibiotics during their labor and delivery course. The administration of intrapartum antibiotics was significantly different between *S. pseudoporcinus* and the GBS groups (63.3% vs 96.8%, P < .001). We attempted to evaluate whether the difference in the morbidity outcomes persisted in patients who did not receive any intrapartum antibiotics. Although all outcome measures were higher in *S. pseudoporcinus* carriers, due to small sample size (*S. pseudoporcinus,* n = 22; GBS, n = 16), no comparison reached statistical significance.

Finally, we looked only within the *S. pseudoporcinus* group to evaluate

TABLE 3
Comparison of maternal and neonatal outcomes in *S. pseudoporcinus* and GBS carriers

	S. pseudoporcinus n = 60	GBS n = 505	*P* value
Maternal morbidity			
Composite maternal morbidity	15 (25)	79 (15.6)	.019
PPROM or spontaneous preterm birth	10 (16.7)	24 (4.8)	<.001
Chorioamnionitis	2 (3.3)	29 (5.7)	.758
PP fever <24 h after delivery	1 (1.7)	31 (6.1)	.348
PP fever >24 h after delivery	3 (5)	8 (1.6)	.077
PP endomyometritis	3 (5)	15 (3)	.239
PP wound infection	1 (1.7)	8 (1.6)	.595
Neonatal morbidity			
Composite neonatal morbidity	15 (25)	95 (18.8)	.099
NICU admission	16 (26.6)	79 (15.6)	.007
Neonatal sepsis	14 (23.3)	85 (16.8)	.082
Respiratory distress syndrome	5 (8.3)	35 (6.9)	.572

Data are n (%).

GBS, Streptococcus agalactiae; NICU, neonatal intensive care unit; *PP,* postpartum; *PPROM,* preterm premature rupture of membranes; *S. pseudoporcinus, Streptococcus pseudoporcinus.*

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whether exposure to intrapartum antibiotics influenced perinatal infectious morbidity. PPROM and spontaneous preterm birth are excluded as outcome variables in this analysis, because this outcome would precede the use of antibiotics and therefore not be influenced by their use. Of the 22 *S. pseudoporcinus* patients who did not receive antibiotics, 4 patients had an infectious morbidity of neonatal sepsis. One of these patients also had postpartum endomyometritis. In the remaining 38 *S. pseudoporcinus* patients who did receive antibiotics, 11 had an infectious morbidity of neonatal sepsis. Three of these same patients also had maternal infectious morbidity including postpartum endomyometritis or maternal sepsis. Although the sample size in these subgroups is small, the data do not indicate that the use of intrapartum antibiotics significantly influenced postpartum infectious morbidity in the *S. pseudoporcinus*–colonized patients.

TABLE 4
Maternal and neonatal morbidity of *S. pseudoporcinus* vs GBS carriers

	Unadjusted relative risk (95% CI)	*P* value	Multivariate adjusted relative risk (95% CI)	*P* value
PPROM or spontaneous preterm birth	3.97 (2.00–7.85)	<.001	4.18 (2.06–8.49)[a]	<.001
NICU admission	1.92 (1.22–3.05)	.005	1.57 (0.99–2.48)[b]	.054
Composite maternal morbidity	1.81 (1.12–2.90)	.014	1.68 (1.00–2.81)[c]	.048

CI, confidence interval; *GBS, Streptococcus agalactiae; NICU,* neonatal intensive care unit; *PPROM,* preterm premature rupture of membranes; *S. pseudoporcinus, Streptococcus pseudoporcinus.*

[a] Adjusted for body mass index, insurance type, smoking status, and history of sexually transmitted infection; [b] Adjusted for PPROM or spontaneous preterm birth, mode of delivery, and intrapartum antibiotic use; [c] Adjusted for body mass index, mode of delivery, and intrapartum antibiotic use.

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Comment

Prior studies have estimated a population prevalence of 5–6% for *S. pseudoporcinus* colonization.[6] Our study demonstrates that *S. pseudoporcinus* colonization in pregnancy is uncommon, representing only 1–2% of pregnant women at our institution. We also identified a 2–3% false-positive rate of GBS screening, where these patients were actually colonized with *S. pseudoporcinus* rather than S. *agalactiae*.

In this large retrospective cohort study, we report different baseline characteristics in carriers of *S. pseudoporcinus* compared to carriers of GBS. We also found differences in perinatal morbidity, primarily in patients presenting with PPROM. Our study confirms that *S. pseudoporcinus* colonization in pregnancy occurs primarily in African American women, supporting theories that vaginal bacterial microbiota may vary among women from different ethnic backgrounds.[10] Although racial disparities also exist in the prevalence of other genitourinary infections, it is possible that this variation in vaginal microbiota may contribute to the acquisition of such infections or vice versa.[11–13]

Prior studies[3,6] have demonstrated that *S. pseudoporcinus* colonization is associated with reproductive age, history of HSV infection, history of Trichomonas, and multiple sexual partners, potentially suggesting co-epidemiology of this bacterium with STIs. Our study demonstrates that tobacco use and BMI ≥35 are predictors of *S. pseudoporcinus* colonization, even after adjusting for other potential confounders. Our data also suggest the possibility of an association among other STIs and *S. pseudoporcinus* colonization. Although our multivariate analysis fails to show that a history of an STI is an independent predictor of *S. pseudoporcinus* colonization, we cannot rule out a relationship in the opposite direction whereby *S. pseudoporcinus* colonization could be a predictor of or a modifying factor for other genitourinary infections. Furthermore, in our subgroup analyses of only African American women, we observed a higher prevalence of BMI $\geq$35, diabetes, and concomitant HSV2 infection in patients with *S. pseudoporcinus*.

S. pseudoporcinus has its own unique genetic identity, and, given its larger zone of hemolysis on culture and its difference in antibiotic susceptibility, this bacterium may behave somewhat differently than GBS. Because of the widespread use of antibiotics and our aggressive intrapartum management of GBS colonization, antibiotic resistance profiles for GBS have continued to increase. Currently, 15−20% of GBS is resistant to clindamycin.[1] We demonstrated a low rate of *S. pseudoporcinus* resistance to clindamycin (5%), suggesting a difference in the behavior of *S. pseudoporcinus* or more limited exposure of *S. pseudoporcinus* to antibiotics. This high susceptibility of *S. pseudoporcinus* to clindamycin is similar to that found in prior smaller studies.[3,4,6]

We identified more women in the *S. pseudoporcinus* group who experienced PPROM or spontaneous preterm birth, a relationship that maintained significance even after controlling for other potential confounders. This finding raises the question as to whether this bacterium directly contributes to this outcome, or whether it modifies or is a marker for other characteristics of the maternal microbiome that may contribute to preterm birth.

S. pseudoporcinus is thought to be biochemically similar to the *S. porcinus* species which was initially isolated in swine.[14] In swine, *S. porcinus* colonized the genital tract and was associated with septicemia and pregnancy losses. Before improved bacterial identification techniques, small series of cases described *S. porcinus* colonization in women and its association with pelvic infections, chorioamnionitis, postpartum endometritis, and maternal and neonatal septicemia. In 2004, Martin et al[15] described a case of a 22-year-old primigravida at 22 weeks 2 days' gestation who presented with painless advanced cervical dilation, intact but bulging membranes, and with no other clinical signs of infection. She progressed to deliver a nonviable fetus. Infectious evaluation revealed histologic chorioamnionitis with heavy growth of *S. porcinus* in the endocervix, the amniotic fluid, fetal rectum, nose, ears, skin, and gastric fluid. Other case reports have also described cervical insufficiency and/or second trimester pregnancy losses in the setting of *S. porcinus* colonization.[16] With advances in bacterial gene sequencing, it is likely that these previously described cases represented colonization with *S. pseudoporcinus.* In considering these case reports and the findings of our study, perhaps *S. pseudoporcinus* colonization has greater implications for preterm birth than for intrapartum or postpartum morbidity.

A major strength of our study is the large sample size, which includes all patients colonized with *S. pseudoporcinus* during pregnancy. Also, chart review was performed in an exhaustive manner, with cross-referencing between neonatal and maternal charts to verify accuracy of the data. Given the nonspecificity and sometimes misleading nature of diagnosis and billing codes, we purposely did not use these codes in our data collection. Instead, we reviewed clinician summaries and objective data within the medical record to optimize the collection of accurate data. In addition, before initiating this study, we validated the use of MALDI-TOF MS for distinguishing *S. pseudoporcinus* from GBS.[17]

A major limitation of our study is that we did not include patients who were negative for both *S. pseudoporcinus* and GBS. Given the exploratory nature of our study, we focused initially on comparing this unique bacterium to another similar and well-studied *Streptococcus* species. Consequently, we cannot comment on the different outcomes in patients with *S. pseudoporcinus* when compared with those who are truly negative for GBS. Finally, our study population reflects the demographics of a large urban population, which affects the generalizability of our results. It is possible that prevalence rates of *S. pseudoporcinus* colonization may vary significantly by regional demographics.

With these limitations in mind and the overall infrequency of *S. pseudoporcinus* colonization in general, we would not advocate for changing our standard screening and treatment protocols for GBS. There may, however, be value in reporting *S. pseudoporcinus* colonization in the record when it is identified. This increased recognition and reporting may aid future clinical research regarding this bacterium. Furthermore, identification of this bacterium in the clinical record may affect a clinician's assessment and management of postpartum or neonatal infections. Future studies would be needed comparing the outcomes of *S. pseudoporcinus* patients and GBS-negative patients. With the laboratory capability available to distinguish between *S. pseudoporcinus* and *S. agalactiae,* prospective data collection of *S. pseudoporcinus* carriers and well-matched *S. agalactiae* carriers and noncarriers could provide a more comprehensive understanding of the pathogenesis of this bacterium.

However, our data and reports from earlier limited studies and case reports raise concern for an association of this bacterium with pregnancy loss and preterm delivery. In clinical practice, these are outcomes that generally occur before acquiring culture data that would drive decision making regarding this initiation of antibiotics. A question that remains unanswered is whether early or persistent colonization with this bacterium increases pregnancy morbidity, when compared to those noncolonized. Examining baseline rectovaginal cultures testing for *S. pseudoporcinus*, particularly in African American patients, may provide insight into whether its presence in the vaginal flora during pregnancy contributes to pregnancy loss, preterm delivery, or infectious morbidities. A better understanding of this relationship would in turn guide decisions as to whether targeted screening for *S. pseudoporcinus* in pregnancy in African American women should be considered.

In summary, it is unlikely that *S. pseudoporcinus* represents a new genitourinary pathogen but, rather, that advances in bacterial identification in clinical microbiology laboratories have allowed us to distinguish different streptococcal subtypes. As our knowledge about these bacteria expands, it becomes important for us to explore the differences in pathogenicity of these bacteria, to review our identification and reporting methods, and to consider the clinical implications associated with treatment or nontreatment of these bacteria. False-positive GBS results may lead to unnecessary antibiotic use and the emergence of antimicrobial resistance patterns in the future. Alternatively, the lack of antibiotic use in these newly described *Streptococcus* species that are reported as GBS negative may also have implications for maternal and neonatal perinatal morbidity. Additional research is needed to examine the association between *S. pseudoporcinus* and pregnancy morbidity, as well the most effective reporting strategies that will ultimately drive decision making on the use of antibiotics. ■

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