

# Predictors and Outcomes for Pregnant Women with Vaginal–Rectal Carriage of Community-Associated Methicillin-Resistant *Staphylococcus aureus*

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## ABSTRACT

The purpose of this study was to determine the predictors and outcomes of pregnant women with vaginal–rectal carriage of community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA). We performed an unmatched 1:4 case-control study with two control groups (13 CA-MRSA cases, 52 methicillin-sensitive *S. aureus* (MSSA) controls, and 52 *S. aureus*-negative controls) via a retrospective medical record review. We found that CA-MRSA cases were 12.5 times significantly less likely to be colonized with group B streptococci (GBS) compared with MSSA controls in multivariable analyses. When we compared MSSA patients with *S. aureus*-negative patients, we found that MSSA patients were 4.5 times significantly more likely to be colonized with GBS and 11 times significantly more likely to have a postpartum fever  $\geq 100.4^{\circ}\text{F}$  in multivariable analyses. Traditional risk factors for hospital-associated MRSA do not appear to predict vaginal–rectal CA-MRSA carriage in pregnant women. Instead, CA-MRSA carriage is significantly associated with lack of GBS carriage. Additional microbiologic studies and epidemiologic studies are needed to clarify the relationship between *S. aureus* and GBS, given that these two colonizing organisms have the potential to become pathogens.

**KEYWORDS:** *Staphylococcus aureus*, methicillin-resistant *S. aureus* (MRSA), community-associated MRSA, group B streptococci (GBS), antibiotic resistance

Community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA) is a growing menace in the United States and elsewhere.<sup>1</sup> CA-MRSA strains are distinct from hospital-associated (HA) MRSA strains in several ways: occurrence in patients without traditional risk factors associated with HA-MRSA<sup>2</sup>; possession of an antibiotic susceptibility pattern with

resistance to fewer classes of antimicrobial drugs<sup>3</sup>; acquisition of the smallest mobile genetic elements (staphylococcal chromosomal cassette *mec* types IV and V) that confer resistance to methicillin<sup>4,5</sup>; possession of distinct genetic fingerprints<sup>6,7</sup>; and often times expression of Panton-Valentine leukocidin, a potent toxin that destroys leukocytes.<sup>8</sup>

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Another striking difference between CA-MRSA strains and HA-MRSA is that CA-MRSA strains are found mainly in children and young adults, whereas HA-MRSA predominantly affects the elderly. CA-MRSA was first described in the United States in 1999, after four unrelated, previously healthy young children in the Midwest died from severe infections caused by the same strain of CA-MRSA.<sup>9</sup> In the 1990s, studies showed a greater than 20-fold increase in the frequency of CA-MRSA infections in children.<sup>10,11</sup> By 2003, CA-MRSA infections in children reached epidemic proportions.<sup>12</sup> CA-MRSA infections also emerged in newborns, including infants hospitalized in neonatal intensive care units.<sup>13,14</sup> Reports of infection and carriage of CA-MRSA among healthy infants in regular nurseries were noted in New York City,<sup>15</sup> Chicago, and Los Angeles.<sup>16</sup> Coincident with the epidemic in children and newborns, CA-MRSA infections appeared in pregnant and postpartum women.<sup>17,18</sup> The risk factors for CA-MRSA infection in children, newborns, and mothers are not well understood.

Given that one of the most important risk factors for subsequent *S. aureus* infection is carriage of the pathogen,<sup>19–22</sup> we determined in a previous study the extent of vaginal–rectal CA-MRSA carriage in a large cohort of pregnant women whose prenatal group B streptococci (GBS) screening cultures were submitted to the clinical microbiology laboratory of a tertiary care facility.<sup>23</sup> From 2963 GBS screening cultures, we identified 507 (17.1%) *S. aureus* isolates, of which 14 of 507 (2.8%) were methicillin resistant. Thirteen of the 14 MRSA isolates had *mec* type IV or V and were classified as CA-MRSA isolates, and one isolate was classified as HA-MRSA. We sought to identify predictors and outcomes in the pregnant women with vaginal–rectal CA-MRSA carriage.

## MATERIALS AND METHODS

We performed an unmatched 1:4 case control study with two control groups to assess for potential predictors and outcomes of 13 CA-MRSA cases, 52 randomly selected methicillin-sensitive *S. aureus* (MSSA) controls, and 52 randomly selected *S. aureus*-negative controls (for a total of 117 individual pregnant women) from the large cohort of pregnant women identified in a previous study.<sup>23</sup> Random selection of controls was performed using SPSS (version 13.0; SPSS Inc., Chicago, IL). At the initiation of the previous study, the study team reviewed the Centers for Disease Control and Prevention guidelines for prevention of neonatal GBS disease during a Department of Obstetrics and Gynecology grand rounds.<sup>24</sup> Emphasis was placed on the importance of obtaining a GBS screening culture in selective broth media of both the lower vagina and rectum of pregnant women between 35 and 37 weeks of gestation and when

patients were at risk for preterm delivery. GBS screening cultures submitted to the clinical microbiology laboratory between January 2005 and July 2005 were cultured for GBS as standard care, and for *S. aureus* as study procedure.<sup>23</sup> This case-control study was approved by the Columbia University Human Subjects Institutional Review Board.

One clinician (H.C.) conducted the retrospective medical record review of the cases and selected controls, blinded to the *S. aureus* status of the pregnant women. Demographic characteristics, medical history, obstetric history, and pregnancy outcomes were obtained. For each case or control, an electronic medical record review was attempted. If an electronic medical record was not used, the handwritten medical record was reviewed.

Given that age is associated with *S. aureus*, MRSA, and CA-MRSA carriage in the general population,<sup>25,26</sup> we collected information on maternal age. We also collected data on race/ethnicity, given that Hispanic persons had statistically significantly less risk than white persons for MRSA carriage.<sup>26</sup> Although most pregnant women in our tertiary care facility were expected to have Medicaid health insurance from a previous finding,<sup>23</sup> which could control for socioeconomic status, insurance status was also collected. Because healthcare exposure is significantly associated with MRSA carriage,<sup>27</sup> the number of healthcare visits including prenatal care visits, outpatient office visits, emergency department visits, and inpatient admissions were calculated within 1 year of GBS culture collection. Because history of chronic medical illness is associated with MRSA and *S. aureus* carriage,<sup>27,28</sup> we differentiated between chronic medical conditions (e.g., asthma, diabetes mellitus, hypothyroidism, and human immunodeficiency virus [HIV] infection) and gestational medical conditions (e.g., gestational diabetes, gestational hypertension). History of surgical procedures is another predictor for MRSA carriage,<sup>27</sup> and so we differentiated between major surgical procedures not including cesarean deliveries (e.g., other abdominal surgery) versus minor surgical procedures (e.g., tonsillectomy). Antibiotic usage prior to GBS culture collection was not directly assessed because reliable information was not available in the records reviewed. However, we recorded a history of infectious disease diagnoses (e.g., urinary tract infection, sexually transmitted infections, and HIV infection). Obstetric characteristics of interest included parity and cesarean delivery, given that pregnant and postpartum women with CA-MRSA infections were more likely to be multiparous and to have had a cesarean delivery.<sup>18</sup> We were also interested in GBS status; our previous study showed a significant association with GBS carriage and *S. aureus* carriage.<sup>23</sup> Given that *S. aureus* carriage is the most important risk factor for subsequent *S. aureus* infection,<sup>19–22</sup> we were interested in outcomes of preterm delivery, intrapartum and

postpartum fever, and infectious complications during the postpartum period.

For analysis of categorical variables (e.g., GBS status, presence of postpartum fever  $\geq 100.4^{\circ}\text{F}$ ),  $\chi^2$  statistics were used, and analysis of variance was used in the analysis of continuous variables (e.g., age). Multinomial logistic regression was performed to control for possible confounders. Results were considered significant at  $p < 0.05$  and Fisher's exact test  $p$  values were reported when values had expected counts of less than five. Analyses were performed with SPSS (version 13.0; SPSS Inc., Chicago, IL).

## RESULTS

When we compared the 13 CA-MRSA cases with the 52 MSSA controls, we found no significant differences in demographic characteristics, medical history, and outcomes in univariable analyses (Table 1). However, CA-MRSA cases were 12.5 times significantly less likely to be colonized by GBS compared with MSSA controls in multivariable analyses adjusted for maternal age, race/ethnicity, and parity (adjusted odds ratio [AdjOR], 12.5; 95% CI, 1.5 to 111.0;  $p = 0.02$ ).

When we compared the 13 CA-MRSA cases with the 52 *S. aureus*-negative controls, we found no significant differences in risk factors (Table 1). However, when we compared the 52 MSSA patients with the 52 *S. aureus*-negative patients, we found that MSSA patients were 4.5 times significantly more likely to be colonized by GBS (AdjOR, 4.5; 95% CI, 1.7 to 11.0;  $p = 0.003$ ) and 11 times significantly more likely to have a postpartum fever  $\geq 100.4^{\circ}\text{F}$  (AdjOR, 11.0; 95% CI, 1.1 to 110.3;  $p = 0.04$ ) in multivariable analyses adjusted for maternal age, race/ethnicity, parity, GBS status, and presence or absence of postpartum fever.

## COMMENT

We reported previously that 13 of 2963 GBS screening cultures submitted to a clinical microbiology laboratory at a tertiary care facility from January to July 2005 contained CA-MRSA.<sup>23</sup> We now report a case-control study of the predictors and outcomes of the same pregnant women with vaginal-rectal CA-MRSA carriage. We found that CA-MRSA cases were significantly less likely to be colonized by GBS as compared with MSSA controls in multivariable analyses. In addition, when we compared MSSA patients to the *S. aureus*-negative patients, we found that MSSA patients were significantly more likely to be colonized by GBS and significantly more likely to have a postpartum fever in multivariable analyses.

Our study is consistent with previous investigations that showed that traditional risk factors for HA-MRSA carriage did not predict CA-MRSA car-

riage.<sup>29,30</sup> However, given that we obtained data from a retrospective chart review of study subjects, we could not elicit information on other traditional risk factors such as antimicrobial exposure in the preceding 6 months or contact with health care workers, persons with known MRSA carriage or infection, or nursing home residents. We also could not assess for other risk factors associated with MRSA carriage, such as history of skin or soft tissue infections or history of illicit drug use. A prospective cohort study is needed with improved assessment of risk factors for CA-MRSA carriage in pregnant women.

The present study did show that CA-MRSA carriage is significantly associated with lack of GBS carriage. This finding is consistent with a previous report of a series of eight postpartum women in our institution who developed skin and soft-tissue infections caused by a CA-MRSA strain.<sup>17</sup> In that study, all of the patients with CA-MRSA infections lacked GBS carriage as compared with 13 of 24 control patients without CA-MRSA infections who delivered at the same time. The strength of the present finding is that we were able to control for factors known to be associated with GBS carriage such as age and race/ethnicity.<sup>31</sup>

In contrast, we also found that MSSA carriage was significantly associated with GBS carriage in multivariable analyses. This association between MSSA and GBS is consistent with prior *in vitro* studies. GBS was shown to inhibit many commensal bacteria of the genital tract with the exception of *S. aureus*, coagulase-negative staphylococci, and gram-negative bacilli.<sup>32</sup> Similarly, *S. aureus* was found to enhance the growth of GBS and select Enterobacteriaceae.<sup>33</sup>

Why is MSSA associated with vaginal-rectal GBS carriage, whereas CA-MRSA is not? We speculate that microbiologic properties of CA-MRSA may lead to inhibition of GBS or vice versa. We also speculate that efforts to prevent neonatal GBS disease<sup>24</sup> or to decrease post-cesarean delivery infections<sup>34</sup> in previous pregnancies may have resulted in a pregnant woman's exposure to antibiotics, which exerted strong selective pressures for the development of antibiotic-resistant strains within the bacterial populations.<sup>35</sup> One prior study showed that pregnant and postpartum women with CA-MRSA infections were more likely to be multiparous and to have had a cesarean delivery.<sup>18</sup> Our study, however, did not show a difference in parity or history of cesarean delivery in pregnant women with vaginal-rectal CA-MRSA carriage as compared with controls. Additional studies should explore the microbiologic and epidemiologic interactions between *S. aureus* (methicillin resistant and methicillin susceptible) and GBS.

We also found that pregnant women with MSSA carriage were significantly more likely in multivariable analyses to have postpartum fever than those women who were *S. aureus* negative. Although the incidence of postpartum infection in the immediate postpartum

**Table 1 Characteristics of Pregnant Women with Vaginal–Rectal Carriage of CA-MRSA, MSSA, and without *S. aureus***

Characteristic	Pregnant Women with Vaginal–Rectal Carriage of		<i>S. aureus</i> –Negative Pregnant Women (n = 52)
	CA-MRSA (n = 13)	MSSA (n = 52)	
Demographic data			
Age (years)*	28.1 (± 7.5)	26.3 (± 7.4)*	29.4 (± 7.4)*
Race/ethnicity <sup>†</sup>			
Hispanic	7 (53.8)	34 (68.0) <sup>†</sup>	21 (40.4) <sup>†</sup>
Other	6 (46.2)	16 (32.0) <sup>†</sup>	31 (59.6) <sup>†</sup>
Insurance status			
Medicaid	12 (92.3)	44 (84.6)	38 (73.1)
Other	1 (7.7)	8 (15.4)	14 (26.9)
Medical history			
Healthcare visits (within 1 year of GBS culture collection)	8.5 (± 6.8)	9.4 (± 5.2)	8.3 (± 5.1)
Chronic medical condition			
Yes	1 (8.3)	7 (14.0)	13 (25.5)
No	11 (91.7)	43 (86.0)	38 (74.5)
History of major surgery			
Yes	0 (0.0)	7 (14.0)	7 (13.7)
No	12 (100.0)	43 (86.0)	44 (86.3)
History of infection diseases diagnoses			
Yes	1 (8.3)	3 (6.0)	6 (11.8)
No	11 (91.7)	47 (94.0)	45 (88.2)
Obstetric history			
Parity			
Multiparous	6 (46.2)	26 (50.0)	23 (44.2)
Nulliparous	7 (53.8)	26 (50.0)	29 (55.8)
History of prior cesarean delivery			
Yes	3 (23.1)	9 (17.3)	7 (13.5)
No	10 (76.9)	43 (82.7)	45 (86.5)
GBS status <sup>‡</sup>			
Positive	1 (7.7) <sup>‡</sup>	26 (50.0) <sup>‡</sup>	9 (17.3) <sup>‡</sup>
Negative	12 (92.3) <sup>‡</sup>	26 (50.0) <sup>‡</sup>	43 (82.7) <sup>‡</sup>
Pregnancy outcomes			
Intrapartum fever ≥ 100.4°F			
Yes	0 (0.0)	4 (8.5)	6 (11.8)
No	13 (100.0)	43 (91.5)	45 (88.2)
Preterm delivery			
Yes	2 (15.4)	3 (5.8)	7 (13.5)
No	11 (84.6)	49 (94.2)	45 (86.5)
Mode of delivery			
Vaginal delivery	10 (76.9)	29 (56.9)	32 (61.5)
Cesarean delivery	3 (23.1)	22 (43.1)	23 (38.5)
Apgar score < 7 at 5 min			
Yes	0 (0.0)	1 (1.9)	0 (0.0)
No	13 (100.0)	51 (98.1)	52 (100.0)
Birthweight (kg)			
	3.2 (± 0.2)	3.3 (± 0.8)	3.2 (± 0.6)
Postpartum fever ≥ 100.4°F <sup>§</sup>			
Yes	1 (8.3)	7 (13.7) <sup>§</sup>	1 (1.9) <sup>§</sup>
No	11 (91.7)	44 (86.3) <sup>§</sup>	51 (98.1) <sup>§</sup>
Infectious complications within the postpartum period			

Table 1 (continued)

Characteristic	Pregnant Women with Vaginal–Rectal Carriage of		<i>S. aureus</i> –Negative Pregnant Women (n = 52)
	CA-MRSA (n = 13)	MSSA (n = 52)	
Yes	0 (0.0)	2 (4.0)	1 (1.9)
No	13 (100.0)	48 (96.0)	51 (98.1)

\* $p < 0.05$  when MSSA compared with *S. aureus* negative.

† $p < 0.01$  when MSSA compared with *S. aureus* negative.

‡ $p < 0.01$  when CA-MRSA compared with MSSA and  $p < 0.01$  when MSSA compared with *S. aureus* negative.

§ $p < 0.05$  when MSSA compared with *S. aureus* negative.

Data are expressed as mean ( $\pm$  standard deviation) or n (%) within given group. Numbers for some variables do not add up to total because of missing data.

CA-MRSA, community-associated methicillin-resistant *S. aureus*; MSSA, methicillin-susceptible *S. aureus*; GBS, group B streptococci.

period did not differ, we were not able to access records for later postpartum periods. In obstetrics, *S. aureus* is recognized as a cause of abdominal wound infections and breast abscesses.<sup>36</sup> Additional studies that elucidate differences in infectious outcomes among women with no *S. aureus* carriage compared with those carrying MRSA or MSSA are needed.

Regarding neonatal outcomes, we only assessed gestational age at delivery, Apgar score less than 7 at 5 minutes, and birthweight. We were not able to assess the risk of infection or transmission from vaginal or rectal CA-MRSA carriage between mother and child. Although there have not been any reports confirming transmission of MRSA from mother to infant either in the intrapartum or early postpartum periods, two case reports suggest the potential for such transmission.<sup>37,38</sup> Risk determinants of infant carriage with *S. aureus* include maternal carriage, breastfeeding, and the number of siblings.<sup>39</sup> The neonatal consequences from maternal vagina–rectal *S. aureus* carriage (methicillin resistant or methicillin susceptible) are poorly understood.

Given that the sample size of cases was limited to 13, we enhanced the power of the study by increasing the number of controls per case to a ratio of 4:1.<sup>40</sup> Our study is also limited in that we did not include a nonpregnant control population. Because the impetus for the study was the concern of adverse neonatal consequences from maternal CA-MRSA carriage, we decided that the initial study would focus on the population of pregnant women. We also could not study CA-MRSA carriage in other body sites, most notably the nares, which is the most frequent carriage site for *S. aureus*.<sup>41</sup>

In summary, we found that certain traditional risk factors for HA-MRSA did not predict CA-MRSA carriage. Instead, CA-MRSA carriage is significantly associated with lack of GBS carriage. The mechanism for this association is not known. In this era of increased antibiotic usage in obstetrics and increased antibiotic-resistant and virulent organisms, we agree with recent recommendations to practice infection control measures such as good hand hygiene, to use antibiotics prudently, to obtain cultures in patients with skin and soft tissue

infections, and to refrain from screening or starting empiric treatment for CA-MRSA.<sup>42</sup> We also suggest additional prospective studies to examine pregnant women with *S. aureus* carriage (methicillin resistant or methicillin susceptible) to improve our understanding of the evolving epidemiology of *S. aureus* in mothers and their infants.

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