Published in final edited form as:
Am J Obstet Gynecol. 2006 February ; 194(2): 381–386.

The association of psychosocial stress and bacterial vaginosis in a longitudinal cohort

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Abstract

Objective—The purpose of this study was to assess the association of psychosocial stress with bacterial vaginosis in a longitudinal sample of nonpregnant women.

Study design—A 1-year prospective longitudinal design was used. Nonpregnant women (n = 3614) aged 15 to 44 years were recruited at routine health care visits. Assessments were conducted quarterly for 1 year and included a standardized pelvic examination, an assessment of clinical symptoms, and an extensive self-report interview.

Results—Psychosocial stress was associated with overall prevalence of (adjusted odds ratio, 1.10; 95% CI, 1.01–1.20) and an increased incidence of (adjusted odds ratio, 1.29; 95% CI, 1.12–1.48) bacterial vaginosis. The association between stress and bacterial vaginosis incidence was not changed appreciably by the control for behavioral and demographic characteristics and was magnified (odds ratio, 2.05; 95% CI, 1.15–3.66) in a case-crossover analysis.

Conclusion—Increased psychosocial stress is associated with greater bacterial vaginosis prevalence and incidence independent of other risk factors.

Keywords

Bacterial vaginosis; Stress; Immune functioning

Bacterial vaginosis (BV) is a condition that is characterized by an alteration in vaginal flora, with reduced concentration of the normally predominant hydrogen peroxide–producing *Lactobacillus* species and high concentrations of Gram-negative and anaerobic bacteria.[1] It is the most common cause of symptomatic vaginal discharge and is present in 10% to 25% of the general population of reproductive age women. The classic symptoms of discharge and odor are reported by only a minority of women with BV.[2] The prevalence of BV varies widely, ranging from 4% in asymptomatic college students to 60% among women attending an sexually transmitted diseases clinic.[3] In addition to being a cause of minor morbidity, there are more serious obstetric and gynecologic sequelae of BV that include preterm birth, low birth weight, chorioamnionitis, and amniotic fluid infection.[4] BV is a risk factor for genital tract

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infection[5] and includes cervicitis,[6] postoperative gynecologic infections,[7] and acquisition of sexually transmitted infections that include HIV.[8]

The cause of BV is poorly understood. It is hypothesized that a decrease in the quantity of lactobacilli removes the source for hydrogen peroxide, which leads to overgrowth by *Prevotella*, *Mobiluncus*, and other anaerobes that produce succinic acid that may inhibit chemotaxis of white blood cells.[9] Elevated vaginal fluid pH, which is characteristic of BV, is due to increased ammonia and decreased lactic acid. There also is increased production of sialidase that cleaves mucin, leading to the homogeneous discharge and allowing enhanced bacterial adhesion while also lysing white blood cells.[9] Women of black ethnicity are at increased risk for BV. Several behaviors that have been shown to increase the relative risk of BV including ≥3 sexual partners,[10] oral sex,[9] and douching practices.[11]

A potential factor that influences susceptibility to infection is the degree of stress that is experienced by an individual. Exposure to chronic stress may impair immune functioning through multiple pathways, particularly through the hypothalamic-pituitary-adrenal axis and the sympathetic-adrenal-medullary axis, which results in the chronic production of glucocorticoid hormones and catecholamines.[12] Stress has been found to be associated with multiple indicators of decreased immune functioning, including decreased response to vaccination,[13] increased upper respiratory infection,[14] impaired wound healing,[15] and progression of human immunodeficiency virus.[16] To date, only one published study has examined the relationship of stress and BV. In this cross-sectional study of pregnant women, subject report of a moderate-to-high level of stress was associated with 2.2 to 2.3 greater odds of BV.[17]

To our knowledge, no study that has been published to date has examined the relationship of stress to BV in a nonpregnant sample or in a longitudinal study. The purpose of this study was to determine whether self-report of psychosocial stress is associated with BV when assessed longitudinally in a sample of non-pregnant women.

Material and methods

Participants

Participants in this study were enrolled in the Longitudinal Study of Vaginal Flora, which was designed to evaluate the natural history of BV and to determine factors that are associated with the acquisition and loss of this condition. Nonpregnant women aged 15 to 44 years were recruited to the study from August 1999 to February 2002 when attending a routine healthcare visit at 1 of 12 clinics in and near Birmingham, Alabama. Exclusion criteria included immunocompromised status, postmenopausal, post-hysterectomy, post-pelvic radiotherapy, long-term antibiotic therapy (daily for at least 30 days), participation in a clinical trial in which antibiotics or topical genital microbicides were administered in a blinded manner, nonfluent in English, plans to move from the area in the next 12 months, or the presence of mental disorder or intellectual limitations that precluded informed consent. Informed written consent was obtained from all participants. The protocol was approved by the Institutional Review Boards of the Jefferson County Department of Health, the University of Alabama at Birmingham, and the National Institute of Child Health and Human Development.

Procedures

Study participants were assessed quarterly for 1 year. Each assessment included a standardized pelvic examination, vaginal samples, and assessment of clinical symptoms; flora were evaluated by Gram stain according to Nugent criteria.[18] Participants also completed an extensive self-report interview that including gynecologic history, hygiene practices, sexual

behaviors, and demographic variables. Perceived psychosocial stress was assessed with the Perceived Stress Scale,[19] a 10-item measure that assesses an individual's stress appraisal in the past 30 days. The 10-item version of this scale has demonstrated superior psychometric properties over the earlier 14-item version.[19] Scale items are phrased as 5-point Likert scales and include the dimensions of overload, uncontrollability, and ability to cope. The measure has good internal consistency ($\alpha = .78$) and has demonstrated reliability and validity across samples that vary in age, race, and socioeconomic status. Scores were calculated as the mean response to scale items, which created a continuous variable that ranges from 1 to 5; results are reported as the odds ratio per 1 point increased score. Trained female interviewers conducted the interviews in a private office. Interviewers were blinded to the results of the physical examination and vice versa; Gram stains were evaluated blind to clinical data.

Analyses

The relationship of psychosocial stress to BV was assessed both as current BV status at each visit (prevalent BV) and as conversion from BV negative to BV positive across 2 consecutive visits (incident BV). BV was defined as a Nugent Gram stain score of ≥ 7.[18] To draw a clear distinction between BV and normal flora, BV negative was defined as a Nugent Gram stain score of ≤ 3; scores in the intermediate range of Nugent Gram stain score 4 to 6 were not included in analyses.

The prevalence analysis assessed the relationship of psychosocial stress to BV status at each visit. All subjects who had Gram stain scores of 0 to 3 or 7 to 10 at ≥ 1 assessments were included in this analysis. The incidence analysis assessed the relationship of psychosocial stress to the development of BV across 2 consecutive visits. Thus, for this analysis, subjects were included if they had at least 2 consecutive visits in which they were either BV negative at both visits (''maintenance'') or BV negative at one visit and BV positive at the subsequent visit (incidence). Intervals that a woman started and finished as BV positive (persistent BV) or started as BV positive and finished as BV negative (remitting BV) were not studied.

Odds ratios and confidence intervals were calculated for each analysis with the coefficients and their standard errors from the GENMOD procedure for fitting generalized linear models of SAS statistical software (version 9; SAS Institute Inc, Cary, NC), first with no covariates, then controlling for demographic and behavioral risk factors. In the generalized linear longitudinal model, robust (empiric) estimates of the standard errors from the generalized estimating equation method[20] are used for the confidence intervals and the computation of the probability values. This accounts for the possible correlation of multiple observations from the same subject. Potential covariates included age, race, income, frequency of vaginal intercourse, number of sex partners, occurrence of a new sex partner, frequency of douching, and use of hormonal contraceptives. All covariates that demonstrated significant ($P < .05$) bivariate relationships were entered into the model and then retained only if they maintained a significant association with the outcome in the full model.

Finally, we conducted a "case-crossover" analysis.[21] Because women were assessed up to 5 times during the study, a subset of the sample had at least one interval that started and ended as BV negative plus at least one interval that started as BV negative and ended as BV positive. Within this subsample, we conducted a case-crossover analysis, selecting the first maintenance interval and first incidence interval for each subject. We compared a woman's stress score at the beginning of the incidence interval to her score at the beginning of the maintenance interval. Because this analysis compares BV incidence in the same woman over time, we report the matched odds ratio for incidence of BV per point change in mean stress score. No demographic and behavioral characteristics demonstrated significant change between the 2 intervals, so no potential covariates were included in the case-crossover analysis. Thus, only unadjusted analyses are presented.

Results

A total of 3620 women were enrolled in the study; initial assessments were completed on 3614 of the women. Subjects completed between 1 and 5 assessments each: 1790 women completed 5 assessments; 519 women completed 4 assessments; 398 women completed 3 assessments; 367 women completed 2 assessments, and 540 women completed 1 assessment, resulting in a total of 13,494 assessments for the study. Across all assessments, a total of 4908 BV-negative classifications and 5425 BV-positive classifications were made; intermediate BV scores occurred at 3096 assessments, and Gram stain results were missing for 65 assessments. Across the 5 assessments, there were a total of 2284 instances in which a women was BV negative at 2 consecutive visits and 449 instances in which a woman was BV negative at one visit and BV positive at the subsequent visit (ie, incident BV). A total of 155 women had both negative and incident intervals across their multiple visits and were the subjects of the case-crossover (matched) analysis.

Demographic and behavioral characteristics of the women and their association with BV prevalence and incidence are presented in Table I. In unadjusted analyses, BV prevalence was associated with the following covariates: age, race, income, frequency of douching, frequency of vaginal intercourse, number of recent sex partners, and use of hormonal contraceptives. BV incidence was associated with age, race, income, frequency of douching, frequency of vaginal intercourse, number of recent sex partners, and occurrence of a new sex partner.

Perceived stress scores ranged from 1.00 to 5.00, with an overall mean across visits of 2.68 ± 0.73 (SD). Thus, a 1-point increase in mean score would represent an increase of 1.37 SDs and be equivalent to an increase from the 25th to the 75th percentile of perceived stress. The mean perceived stress score for those women who were BV negative was 2.63; the mean score for those women who were BV positive was 2.71 (P = .0003). The mean perceived stress score for those women who maintained a BV-negative status across 2 visits was 2.58; the mean score for those women in whom BV developed was 2.71 (P = .0005). Correlations among perceived stress at each of the 5 visits ranged from 0.26 to 0.49, with a mean correlation of 0.34.

In the prevalence analysis, psychosocial stress demonstrated a small but significant relationship with BV prevalence in unadjusted analysis (Table II). Each 1-point increase in the 5-point stress scale was associated with 1.15 greater odds of being BV positive. The relationship remained significant after being controlled for frequency of douching, frequency of vaginal intercourse, number of sex partners, use of hormonal contraceptives, race, and income (odds ratio, 1.10).

In the incidence analysis, a larger association between psychosocial stress and BV was associated with conversion from BV negative to BV positive across 2 consecutive visits (Table III). A 1-point increase in the stress measure was associated with 1.28 greater odds of BV incidence. This relationship was nearly identical (odds ratio, 1.29) after being controlled for the frequency of vaginal intercourse, the number of sex partners, and race. Other potential risk factors did not remain associated with BV incidence in the model.

In the case-crossover analysis, which included only with women having both negative and incident intervals across the 5 visits (n = 155), a substantially stronger association between psychosocial stress and BV incidence was observed (Table III). In this subsample, the mean perceived stress score for negative intervals was 2.58; the mean stress score for incident intervals was 2.70. The matched odds ratio associated with a 1-point increase in psychosocial stress was 2.05.

Comment

To our knowledge, this is the first longitudinal study that has assessed the relationship of psychosocial stress and BV. A small but significant effect of stress on overall BV status was observed after adjustment for behavioral and demographic covariates; however, there was a greater effect of stress on BV incidence (defined as conversion from BV negative to BV positive over a 3-month interval). This effect remained essentially unchanged after adjustment for behavioral and demographic covariates and increased in magnitude in a case-crossover analysis. By controlling for individual factors such as individual differences in stress reactivity and immune functioning, the case-crossover analysis may be a more powerful analytic strategy and more accurately reflect the effect of psychosocial stress on the development of BV.

It is notable that the effect of stress was greater on BV incidence than prevalence, which suggests that the effect is related to the development of the condition rather than its maintenance over time. In addition, the magnitude of the relationship was not diminished appreciably by the inclusion of behavioral and demographic covariates. Indeed, behavioral risk and protective factors were not significantly different between time points in the case-crossover analysis. These findings suggest that the effect of stress on the development of BV may be mediated by stress-related changes in immune functioning, rather than being explained by changes in behavior that is associated with stress. This explanation is supported by recent findings that BV is more common among women with genetic polymorphisms that make them under-respond to immune stimuli.[22]

Our findings are less robust from those of Culhane et al,[17] who found that psychosocial stress was more strongly associated with BV prevalence in a cross-sectional sample of pregnant women. Although there were some differences in measurement between the 2 studies (Culhane et al used the 14-item version of the Perceived Stress Scale and analyzed by quartiles), these minor differences alone are insufficient to account for the difference in degree of association found between the 2 studies. The more likely explanation is that the degree of association may differ in the 2 populations, such that the effect of stress on BV is greater during pregnancy.

We did not obtain physiologic measures of either stress or immune functioning. Self-report of stress has several advantages over physiologic measures such as cortisol. The self-report measure that was used in this study assesses stress appraisal over the past month. Cortisol measurement would have been limited to an individual assessment on the day of the clinic visit, which may have little correspondence to the level of stress that had been experienced over the preceding month. Previous research has found that daily stressful events correspond to same-time cortisol measurements, but not past-month perceived stress.[23] Moreover, the effects of stress on immune function may not be limited to those effects that are mediated by cortisol secretion. Previous research has demonstrated stress-related changes in immune-inflammatory variables that are not associated with serum cortisol concentrations.[24] Because physiologic measures of immune functioning were not conducted in this study, we cannot determine whether in fact a subject's report of stress corresponded to a decrement in immune functioning. However, the body of research on the influence of psychosocial stress in immune functioning clearly supports this relationship.[24,25]

These findings concur with the body of literature that documents an adverse effect of stress on susceptibility to infection. Because the cause of BV is poorly understood, the determination of factors that may contribute to its development may prove useful both in better advancing our understanding of and in preventing this condition. Future research on the mechanisms by which stress increases susceptibility to BV is needed.

Acknowledgements

Supported by contract NO-1-HD-8-3293 from the National Institutes of Health.

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Table I

Association of demographic and behavioral characteristics with BV prevalence and incidence

	BV prevalence*				BV incidence†			
	Negative (n = 4908)	Positive (n = 5425)	Odds ratio‡	95% CI‡	Maintenance (n = 2284)§	Incidence (n = 449)‖	Odds ratio‡	95% CI‡
Mean psychosocial stress (n)¶	2.6	2.7	1.15	1.07–1.24	2.6	2.7	1.28	1.11–1.47
Mean age (y) ¶	25.6	26.1	1.01	1.00–1.02	26.1	25.1	0.98	0.96–1.00
Race (%)								
Black	73.0	90.0	3.31	2.80–3.91	71.7	85.5	2.34	1.75–3.12
White/other	27.0	10.1	——	——	28.3	14.5	——	——
Monthly income (%)								
<$500	17.8	23.1	2.61	1.96–3.48	17.0	20.4	1.80	1.13–2.86
$500–$800	27.0	32.1	2.38	1.81–3.14	25.9	28.0	1.61	1.03–2.52
$801 – $3000	45.6	40.0	1.76	1.35–2.30	46.1	44.2	1.43	0.93–2.19
>$3000	9.7	4.8	——	——	11.0	7.4	——	——
Hormonal contraceptive use (%)	56.4	42.7	0.58	0.51–0.65	56.7	56.3	0.98	0.79–1.23
Frequency of douching (%)								
Never	65.7	48.9	——	——	69.8	61.4	——	——
<1/Wk	27.1	38.6	1.91	1.69–2.15	24.1	28.9	1.36	1.07–1.73
>1/Wk	7.2	12.5	2.33	1.94–2.81	6.1	9.6	1.80	1.22–2.66
Frequency of vaginal intercourse (%)								
<1/Wk	46.6	38.80	——	——	52.3	41.3	——	——
1–3/Wk	43.1	47.15	1.31	1.18–1.46	40.7	46.2	1.44	1.15–1.80
4–7/Wk	10.3	14.05	1.64	1.39–1.92	7.1	12.6	2.25	1.57–3.22
Mean no. of sex partners¶	0.9	1.0	1.29	1.17–1.42	0.8	0.9	1.60	1.28–1.99
New sex partner (%)	7.3	8.5	1.19	0.99–1.42	7.0	10.3	1.53	1.08–2.16

*Refers to the number of assessments.

†Refers to 2 consecutive assessment intervals.

‡Odds ratios and 95% confidence intervals calculated from the generalized estimating equation model for the estimates and account for non-independence of assessments within the same subject.

§Defined as 2 consecutive BV negative assessments.

‖Defined as a BV negative assessment followed by a consecutive BV positive assessment.

¶Calculated for continuous variables.

Am J Obstet Gynecol. Author manuscript; available in PMC 2008 May 5.

Table II

Association of psychosocial stress with BV prevalence*

	Odds ratio†	95% CI†
Unadjusted analysis:		
Stress (per point)	1.15	1.07–1.24
Adjusted analysis:		
Stress (per point)	1.10	1.01–1.20
Frequency of douching		
Never	Reference	——
<1/wk	1.64	1.44–1.87
≥1/wk	1.87	1.53–2.29
Frequency of vaginal intercourse		
<1/Wk	Reference	——
1–3/Wk	1.20	1.07–1.35
3–7/Wk	1.64	1.37–1.96
No. of sex partners	1.14	1.03–1.26
Hormonal contraceptive use	0.60	0.53–0.68
Black race	3.50	2.91–4.22
Monthly income		
<$500	2.12	1.57–2.87
$500 – $800	1.93	1.44–2.59
$801 – $3000	1.63	1.23–2.17
>$3000	Reference	——

* Based on 4908 BV negative assessments and 5425 BV positive assessments; 3096 assessments with intermediate Gram stains were excluded.

† Computed from generalized estimating equation logistic models.

Table III

Association of psychosocial stress with BV incidence*

Variable	Odds ratio†	95% CI†
Unadjusted analysis:		
Stress (per point)	1.28	1.11–1.47
Adjusted analysis:		
Stress (per point)	1.29	1.12–1.48
Frequency of vaginal intercourse		
<1/Wk	Reference	——
1–3/Wk	1.35	1.05–1.72
3–7/Wk	2.46	1.69–3.57
No. of sex partners	1.46	1.14–1.87
Black race	2.79	2.08–3.76
Case-crossover analysis:		
Stress (per point) ‡	2.05	1.15–3.66

* Unadjusted and adjusted analyses are based on 2284 intervals that consisted of 2 consecutive BV negative assessments and 449 intervals that consisted of a BV negative assessment followed by a consecutive BV positive assessment.

† Computed from generalized estimating equation logistic models for all analyses.

‡ Based on 155 women who demonstrated both intervals.