

ORIGINAL STUDY

Bacterial vaginosis diagnosis and treatment in postmenopausal women: a survey of clinician practices

Katrina S. Mark, MD,¹ Beatriz Tenorio, MD,¹ Christina A. Stennett, MPH,^{2,3}
Khalil G. Ghanem, MD, PhD,⁴ and Rebecca M. Brotman, PhD, MPH^{2,3}

Abstract

Objective: Some diagnostic features of the genitourinary syndrome of menopause (GSM) and bacterial vaginosis (BV) overlap, such as low levels of vaginal *Lactobacillus* and pH > 5. We sought to determine clinicians' diagnostic and treatment practices for postmenopausal women presenting with BV and GSM scenarios and how commercial molecular screening tests are utilized.

Methods: Anonymous surveys were sent to practicing women's health clinicians to evaluate assessment and treatment strategies for postmenopausal women presenting with BV and GSM scenarios.

Results: When given a scenario of a postmenopausal woman with symptoms overtly positive for BV, a majority of providers (73%) would conduct a wet mount, though only 35% would evaluate full Amsel's criteria. A majority (89%) recommended treatment with antibiotics, 28.2% recommended vaginal estrogen in addition to antibiotics, and 11.8% recommended vaginal estrogen alone. Of providers who would use a molecular swab, 30% would wait for results before treating the patient's symptoms. When given a scenario of a postmenopausal woman presenting with GSM, a majority (80%) recommended vaginal estrogen, and only 4.6% recommended antibiotics. Few (16%) responders would evaluate with a molecular swab, half of whom would wait for results before prescribing treatment. Clinicians in practice for less than 10 years were more likely to rely on molecular swabs than those who had been practicing longer ($P < 0.0003$).

Conclusions: Methods used to evaluate postmenopausal women with vaginal symptoms vary. Future studies of postmenopausal women that differentiate diagnostic criteria between BV and GSM, and validate commercial molecular testing for BV in women over age 50 are needed.

Key Words: Bacterial vaginosis – Diagnostic – Genitourinary syndrome of menopause – Molecular testing.

Bacterial vaginosis (BV) is characterized, in part, by low relative abundance of key *Lactobacillus* spp. and high levels of anaerobic and facultative bacteria.¹ The common presenting symptoms of BV are abnormal vaginal discharge and fishy odor, although half of women with BV are asymptomatic.² Among reproductive-age women, BV has a US prevalence of 29% and is a common cause of abnormal vaginal discharge.^{3,4} Reports of BV

prevalence in postmenopausal women vary more widely (5.4%-38%), likely because the standard criteria for diagnosis are more relevant for premenopausal women.⁴⁻⁹

Several modalities are available for diagnosis of BV. Although rarely used in the clinical setting, Nugent's method of Gram stain scoring is a standardized classification system for identifying BV samples based on morphology.⁸ Amsel's clinical criteria, which can be performed as point-of-care testing, is more commonly used by clinicians due to its ease and immediacy of results that can aid in management decisions. Amsel's criteria has moderate reproducibility compared with Nugent scoring, with sensitivity ranging from 37% to 70% and specificity ranging from 94% to 99%.¹⁰ Where Amsel's criteria relies on symptoms, clinical evaluation, in-office microscopy, and pH testing for determination of BV, Gram-stain scoring requires a sample to be sent to a laboratory for microscopy. Nugent scoring is typically only used in research settings and provides only morphological information, which provides limited insight into the composition of the vaginal microbiota.

Nucleic acid amplification tests (NAAT) for vaginitis (vulvovaginal candidiasis and BV) have emerged and are

Received November 15, 2019; revised and accepted December 19, 2019. From the ¹Department of Obstetrics and Gynecology, University of Maryland School of Medicine, Baltimore, MD; ²Department of Epidemiology and Public Health, University of Maryland School of Medicine, Baltimore, MD; ³Institute for Genomic Sciences, University of Maryland School of Medicine, Baltimore, MD; and ⁴Division of Infectious Diseases, Johns Hopkins School of Medicine, Baltimore, MD.

Funding/support: NIAID R01-AI119012.

Financial disclosure/conflicts of interest: None reported.

Supplemental digital content is available for this article. Direct URL citations are provided in the HTML and PDF versions of this article on the journal's Website (www.menopause.org).

Address correspondence to: Katrina S. Mark, MD, 11 S Paca Street, Suite 400, Baltimore, MD 21201. E-mail: kmark@som.umaryland.edu

becoming increasingly used in clinical applications. As an infectious correlate has not been identified in BV, these nucleic acid tests quantify loads for a panel of various bacteria, including *Gardnerella vaginalis*, *Atopobium vaginae*, BV-associated bacteria (BVAB), and others such as *Megasphaera phylotype 1* and 2. The tests may also distinguish multiple types of *Lactobacillus* spp. including *Lactobacillus crispatus*, *Lactobacillus gasseri*, and *Lactobacillus jensennii*.¹⁰ The tests report either binary positive/negative or a risk category of low/moderate/high risk for BV with certain *Lactobacillus* species being protective against BV diagnosis and the other bacteria as more indicative of BV.

The diagnosis and treatment of BV in postmenopausal women is not standardized. The vaginal microbiota in postmenopausal women is known to have a different makeup compared with reproductive-aged women. In general, postmenopausal women have lower levels of estrogen and glycogen in the vaginal mucosa, and also thinner vaginal epithelium, lower levels of *Lactobacillus*, and higher microbial diversity and higher vaginal pH.¹¹⁻¹⁵ However, 20% to 50% of postmenopausal women do retain *Lactobacillus* spp.^{16,17} Given that the natural physiology of aging can mimic some of the same changes seen in BV, the validity of the standard diagnostic criteria in postmenopausal women is unclear. The original studies that developed both the Nugent scoring and Amsel's criteria—the two most commonly accepted forms of diagnosis for research and clinical purposes—excluded menopausal women. As one of these two methods are used as the standard diagnostic criteria against which all subsequently developed diagnostic tools are compared and validated, the optimal method for diagnosing BV in postmenopausal women is unknown. The utility of the Nugent scoring system in postmenopausal women has recently been called into question, given that many women will have an abnormal score with no pathology or symptoms detectable.^{4,6} In benchmarking of NAAT studies for BV, postmenopausal women were either explicitly excluded or represented a small proportion and were not analyzed separately.¹⁸⁻²³ Consequently, it is unclear how molecular diagnostics tests for BV are utilized in postmenopausal women.

We sought to survey healthcare practitioners who treat menopausal women to determine their practice patterns regarding diagnostic approaches, and specifically, use of molecular assays for detection of BV in postmenopausal women.

METHODS

Survey design

The study survey consisted of nine demographic questions involving provider training, practice setting, experience, and education, and also 14 content-based questions. These questions were sent to eight practicing OB/GYNs for comment and validation before release. The content-based questions were divided into three sections: scenario 1 regarding evaluation and management of a menopausal woman with symptoms of BV; scenario 2 regarding evaluation and management of a postmenopausal woman with genitourinary syndrome of

menopause (GSM)²⁴; and questions to assess clinician use of molecular assays (see Survey, Supplemental Digital Content 1, <http://links.lww.com/MENO/A548>, which contains the survey questions sent to potential participants). RedCap was utilized as the method of survey distribution and data collection. The survey was e-mailed to providers with a link that included a consent page followed by the survey. The survey responses were anonymous.

An incentive of a \$10 Amazon e-gift card was given to participants who completed the survey. The initial surveys were sent in November, 2017, and data collection was concluded in April, 2018.

Recruitment

An e-mail explaining the study was sent to 400 physicians and certified nurse midwives who practice in the fields of Obstetrics and Gynecology, Family Medicine, and Internal Medicine. The providers were selected by identifying those whose e-mail addresses were publicly available via their institutions websites. Additionally, information regarding the study was posted on a private, national social media group of female physician members. Program directors of all accredited Obstetrics and Gynecology residency programs were also sent information and encouraged to send the e-mail to the members of their residency programs. Interested clinicians were asked to send an e-mail to the study coordinator using their work e-mail address to verify authenticity of their employment. Those who contacted the study coordinator were sent an individualized link to a REDCap survey.

Ethical approval

This survey was approved by the University of Maryland Baltimore Human Research Protections Office. No patient data were collected.

Statistical analysis

Data were analyzed using SAS Studio software. Incomplete surveys were defined as those who did not complete the content-based questions. To determine correlations between swab use for diagnosis and demographic features of survey responders, we used chi-square analysis to calculate *P* values. For survey responses, we calculated frequencies and column percentages of individuals choosing a response in each question.

RESULTS

Of the 382 surveys that were distributed, 172 were initiated and 152 (39.8%) were completed. The large majority of respondents practice Obstetrics and Gynecology, and 65% reported less than quarter of their practice visits were with menopausal women. Practice settings and number of years of experience were distributed (Table 1).

Scenario 1: bacterial vaginosis

The first scenario described a 60-year-old woman with vaginal discharge, itching and dyspareunia, and pale vaginal mucosa. When asked the next step in their workup of a woman

TABLE 1. Demographics of providers who completed the survey

| Characteristics | Total (N = 152) | % of population |
|-----------------------------|-----------------|-----------------|
| OB/GYN specialty | 146 | 96.05 |
| NAMS-qualified? | 10 | 6.57 |
| Experience | | |
| In training | 51 | 33.55 |
| 1-5 y out of training | 37 | 24.34 |
| 5-10 y out of training | 35 | 23.02 |
| >10 y | 29 | 19.07 |
| Practice setting | | |
| Community hospital | 43 | 28.28 |
| Teaching hospital | 106 | 69.73 |
| Hospital-affiliated clinic | 36 | 23.68 |
| Private practice | 19 | 12.5 |
| Postmenopausal patient care | | |
| 0%-25% | 98 | 64.67 |
| 25%-50% | 31 | 20.39 |
| 50%-75% | 15 | 9.86 |
| 75%-100% | 8 | 5.26 |

The providers who were not OB/GYN-trained had a background in family medicine (2), internal medicine (3), and other—not specified (1). NAMS, North American Menopause Society.

with this presentation, 73.0% reported that they would do a wet mount with 35.5% indicating that they would evaluate all of Amsel’s criteria, 19.7% indicating that they would do a wet mount and a molecular swab simultaneously, and 11.8% would use a molecular swab as their only test (Table 2).

Overall, 89.4% of respondents recommended treatment with either oral or vaginal antibiotics, most commonly oral metronidazole (Table 3). Additionally, 61 respondents (40.1%) recommended treatment with vaginal estrogen. Of these, 18 (29.5% of the subset recommending estrogen, 11.8% of the total cohort) would treat with vaginal estrogen alone and 43 (70.5% of the subset recommending estrogen, 28.2% of the overall cohort) recommended dual treatment with vaginal estrogen plus oral and/or vaginal antibiotics. Only the respondents who chose wet mount (n = 111) as part of their initial diagnosis were given the information that the patient was overtly positive for all components of Amsel’s criteria. Of this subset of respondents, 98.2% would treat with oral or vaginal antibiotics, most commonly metronidazole.

TABLE 2. Diagnostic testing choice for postmenopausal woman with bacterial vaginosis (scenario 1) and genitourinary syndrome of menopause (scenario 2)

| | Scenario 1: bacterial vaginosis, % (n) | Scenario 2: GSM, % (n) |
|-----------------------|---|---------------------------|
| No diagnostic testing | 9.86 (15) | 49.34 (75) |
| Wet prep (total) | 73.02 (111) | 36.84 (56) |
| Wet prep alone | 30.26 (46) | 7.89 (12) |
| + Whiff test | 42.76 (65) | 3.95 (6) |
| + Whiff test, pH | 35.52 (54) | 11.18 (17) |
| + Swab | 19.73 (30) | 7.89 (12) |
| + GC/CT testing | 12.50 (19) | 5.92 (9) |
| BV swab alone | 11.84 (18) | 8.50 (13) |
| pH alone | 1.31 (2) | 1.97 (3) |
| Prefer not to answer | 3.95 (6) | 3.29 (5) |

Breakdown of diagnostic tool combinations.

% Column was calculated by the rate a diagnostic tool was chosen by the surveyed providers.

BV, bacterial vaginosis; GC/CT, neisseria gonorrhoea and chlamydia trachomatis; GSM, genitourinary syndrome of menopause.

TABLE 3. Treatment for postmenopausal woman with bacterial vaginosis (scenario 1) and genitourinary syndrome of menopause (scenario 2)

| Treatment choices ^a | Scenario 1: BV, % (n) | Scenario 2: GSM, % (n) |
|--|--------------------------|---------------------------|
| No treatment | 2.63 (4) | 1.31 (2) |
| No empiric treatment; awaiting results | 11.18 (17) | 9.86 (15) |
| Oral antibiotics | 63.81 (97) | 2.63 (4) |
| PO MTZ only | 59.21 (90) | 1.97 (3) |
| PO clindamycin + MTZ | 4.60 (7) | 0.66 (1) |
| Vaginal antibiotics | 25.6 (39) | 1.31 (2) |
| V MTZ only | 21.05 (32) | 1.31 (2) |
| V clindamycin only | 0.66 (1) | 0 |
| V MTZ + clindamycin | 3.95 (6) | 0 |
| Boric acid vaginal suppository | 2.63 (4) | 1.97 (3) |
| Vaginal estrogen | 40.13 (61) | 80.92 (123) |
| Vaginal estrogen only | 11.8 (18) | 78.95 (120) |
| +PO antibiotics | 21.05 (32) | 1.31 (2) |
| +V Antibiotics | 8.55 (13) | 0.66 (1) |
| PO estrogen | 1.97 (3) | 1.31 (2) |
| Probiotics | 6.57 (10) | 1.31 (2) |
| Vaginal lubricants | 19.73 (30) | 36.84 (56) |
| Other | 2.63 (4) | 1.31 (2) |

The above table shows each treatment tool option and its selection rates by surveyed providers (N = 152) regarding how they would treat scenarios 1 and 2.

BV, bacterial vaginosis; GSM, genitourinary syndrome of menopause; MTZ, metronidazole; PO, oral; V, vaginal.

^aCategories are not mutually exclusive.

Additionally, 34 respondents (30.6%) would treat with vaginal estrogen. Of these, none would treat with vaginal estrogen only; all would treat the patient with a combination of vaginal estrogen and oral or vaginal antibiotics. A small amount of those who initially used wet mount microscopy for diagnosis (1.8%) reported that they would still send a follow-up molecular swab after the results were given that were overtly positive for all of Amsel’s criteria. Of this population (n = 2), both chose to treat with oral metronidazole before the results of the molecular test being available.

Of the respondents who would order a molecular swab (n = 56), 18 of them (32.1%) would use the swab as their only test and 17 (30.3%, 10.8% of overall cohort) would not recommend treatment until the results of the swab were available. Of those who would order/perform other tests in addition to the swab, all of them would recommend treatment before receiving the swab results. The most common treatments offered (n = 38) were vaginal estrogen alone (18.4%), oral or vaginal antibiotics (57.9%), or a combination of antibiotics and vaginal estrogen (23.6%). Nearly all respondents (94.4%) who would use the swab as their only test reported that they would wait until the results of the swab were available before recommending treatment.

Scenario 2: genitourinary syndrome of menopause

In the second scenario, a 62-year-old woman presents with the complaint of intermittent vaginal irritation and is found to have pale vaginal mucosa on examination. Given these findings, approximately half of respondents (49.3%) reported that they would order no further diagnostic testing (Table 2). For those who would order testing, 36.84% would perform a wet

mount and 16.44% indicated that they would send a molecular swab. Of those who chose to send a molecular swab, 43.4% of those would do the swab as their only test. Respondents who chose wet mount as a diagnostic tool were given information that it was unremarkable and the vaginal pH was 6.

For treatment, most respondents (80.9%) reported that they would recommend vaginal estrogen, and 36.8% reported that they would recommend vaginal lubrication with or without estrogen (Table 3). A small percentage of respondents (4.6%) would recommend treatment with oral or vaginal antibiotics; of note, all of these respondents would also chose to send a molecular swab. Of the respondents who chose to send a molecular swab, 48% of them would await results before offering treatment, which represented 7.9% of the overall respondents.

Use of molecular swabs

Over half (57.6%) of respondents reported using molecular swabs when evaluating women with vaginal symptoms, with 18.4% of respondents reporting using them 75% to 100% of the time. Only 2.0% reported restricting their use to premenopausal women. Type of practitioner, geographic location of practice, and practice setting were not statistically significantly related to likelihood of reporting use of molecular swabs. Those respondents who were in training or had been in practice for less than 10 years were significantly more likely (odds ratio [OR] 5.58, 95% confidence interval [CI] 2.20-14.18, $P < 0.0003$) to use swabs for diagnosis than those with greater than 10 years of experience.

The reasons given for choosing to use molecular swabs were varied. Almost a third (29.9%) of practitioners believe that molecular swabs are more accurate than clinical diagnosis, and 31% reported that they rely on these tests because they do not have access to a microscope. The most common response (43.7%) was that respondents use molecular swabs when they are unable to make a definitive diagnosis clinically.

Over one quarter of respondents (26.4%) believed that the commercial swabs cost less than \$100, and one-third (33.3%) of respondents had no knowledge of the cost. Only 6.9% of respondents believed that the tests cost \$300 or more.

DISCUSSION

Our study found that the practice patterns regarding methods used to evaluate postmenopausal women with vaginal symptoms is variable. Overall frequency of use and reasons for use of molecular tests for diagnosis of vaginal symptoms also varied among practitioners.

The finding in our study that there are very few practitioners who restrict their use of molecular BV screening tests to premenopausal women is notable. None of the molecular test manufacturers give specific age ranges for use of the swabs (BD Affirm VPIII Microbial Identification Test; BD MAX Vaginal Panel Package Insert; Aptima Vaginal Swab Specimen Collection Kit Package Insert; NuSwab: Smart Testing Has Arrived; SureSwab, Vaginosis/Vaginitis Plus). The studies performed for validation of these molecular assays do not exclude postmenopausal women, but none

specify menopausal status of participants or analyze menopausal women separately. As most enroll through sexually transmitted infection screening clinics, it is very likely that menopausal women are under-represented in these studies. Of the five largest studies, one excludes women over 50,²¹ one reports age range 19 to 67 with median age of 25,²² one reports mean age of 34 with no range given,¹⁹ and one reported only a range of 17 to 55 with no breakdown or average age reported.²⁰ Only one study gives specifics regarding the ages of women enrolled, and this study reported 4.2% of participants were over the age of 50.¹⁸ Two additional studies are referenced in the BDMax guide; one specifies that it included only reproductive-aged women and the other includes only pregnant women.²⁵⁻²⁷

There is biological plausibility for the concern that the validity of molecular tests for diagnosis of BV may differ in pre versus postmenopausal women. Postmenopausal women are significantly less likely to have vaginal microbiota dominated by *Lactobacillus* spp., and as many as a third of postmenopausal women have no detectable *Lactobacillus* spp.^{4,6,11,19,28} Given that molecular assay panels evaluating for BV utilize *Lactobacillus* in their algorithms, specific validation in postmenopausal women would be prudent.

Given the lack of clarity in how to interpret traditional testing for BV when evaluating a postmenopausal woman, it is possible that practitioners are turning to molecular tests in search of a more sensitive and specific diagnostic tool. This is evidenced by the fact that nearly a third of our respondents report their reason for use of molecular tests to be increased perceived accuracy in diagnosis and almost half use molecular tests when they are unable to make a diagnosis based on clinical findings. However, in postmenopausal women, the molecular assay may be identifying a normal physiology rather than BV, and additional validation and reporting metrics may be needed to avoid misinterpretation of these results by clinicians.

This study also elucidates other potential issues with the use of molecular tests in the evaluation of vaginal symptoms. The reliance of some practitioners on molecular assays rather than point-of-care testing may lead to a delay in treatment of symptomatic women. Although the sensitivity of clinical diagnosis is shown to be rather low in many studies, the specificity is typically high, particularly with a positive whiff test and elevated pH.^{29,30} In both clinical scenarios given in this study, nearly 1 in 10 practitioners would not treat at the initial visit, but would await results of a molecular swab, despite a combination of symptoms and physical examination findings that are classically found in BV and GSM. Given the high specificity of clinical diagnosis, there is likely little clinical utility or cost benefit to performing these molecular assays in these scenarios, and awaiting the results of these assays before offering treatment may lead to unnecessary delays.

Additionally, few practitioners had an accurate understanding of the potential costs of these molecular studies. Although the rates that are negotiated by insurance companies are not publicly available, the standard costs without insurance for

these tests range from \$300 to \$1,200 (personal communication with representatives).

The optimal treatment for a BV-like presentation in postmenopausal women is also unknown. We found that many practitioners chose to treat with antibiotics, and also local estrogen. Although vaginal estrogen as treatment or prevention of BV has not been specifically studied, there are studies showing that hormone therapy in menopausal women increases the abundance of *Lactobacillus* spp.^{6,31}

There are of course limitations to this study. The survey was composed of multiple-choice questions that did not allow comment and may not have captured all of the nuances present in clinical care. As with any survey, respondent bias may affect the results. As less than 40% of those who received a survey responded and the demographics of those who did not respond could not be obtained. Many of the respondents were in training, and most have a relatively small percentage of postmenopausal women in their practice. Given this, it is unclear how the cohort of respondents compares with the larger population of Women's Health practitioners. However, it is possible that including a cohort of practitioners who are not subspecialized in menopausal care actually increases the generalizability of the results.

CONCLUSIONS

In summary, our study identified variations in practice in both evaluation and treatment of BV and GSM in menopausal women. This highlights the need for future studies that differentiate between changes in vaginal bacteria in menopause and the most effective way to treat a symptomatic and often low-*Lactobacillus* state in menopause.

REFERENCES

- Hillier SL, Holmes KK, Marrazzo JM. *Bacterial Vaginosis*. *Sex Transm Dis*. New York: McGraw-Hill: Health Professions Division; 2008; p. 737-68.
- Klebanoff M, Schwebke J, Zhang J, Nansel T, Yu K, Andrews W. Vulvovaginal symptoms in women with bacterial vaginosis. *Obstet Gynecol* 2004;104:267-272.
- Sobel JD. Vaginitis. *N Engl J Med* 1997;337:1896-1903.
- Koumans EH, Sternberg M, Bruce C, et al. The prevalence of bacterial vaginosis in the United States, 2001-2004: associations with symptoms, sexual behaviors, and reproductive health. *Sex Transm Dis* 2007;34:864-869.
- Hoffmann JN, You HM, Hedberg EC, Jordan JA, McClintock MK. Prevalence of bacterial vaginosis and *Candida* among postmenopausal women in the United States. *J Gerontol B Psychol Sci Soc Sci* 2014;69 Suppl 2:S205-S214.
- Cauci S, Driussi S, De Santo D, et al. Prevalence of bacterial vaginosis and vaginal flora changes in peri- and postmenopausal women. *J Clin Microbiol* 2002;40:2147-2152.
- Burton JP, Reid G. Evaluation of the bacterial vaginal flora of 20 postmenopausal women by direct (Nugent score) and molecular (polymerase chain reaction and denaturing gradient gel electrophoresis) techniques. *J Infect Dis* 2002;186:1770-1780.
- Nugent R, Krohn M, Hillier S. Reliability of diagnosing bacterial vaginosis is improved by a standardized method of Gram stain interpretation. *J Clin Microbiol* 1991;29:297-301.
- Amsel R, Totten PA, Spiegel CA, Chen KC, Eschenbach D, Holmes KK. Nonspecific vaginitis. Diagnostic criteria and microbial and epidemiologic associations. *Am J Med* 1983;74:14-22.
- Coleman JS, Gaydos CA. Molecular diagnosis of bacterial vaginosis: an update. *J Clin Microbiol* 2018;56. pii: e00342-18.
- Muhleisen AL, Herbst-Kralovetz MM. Menopause and the vaginal microbiome. *Maturitas* 2016;91:42-50.
- Farage M, Maibach H. Lifetime changes in the vulva and vagina. *Arch Gynecol Obstet* 2006;273:195-202.
- Sturdee DW, Panay N. Recommendations for the management of postmenopausal vaginal atrophy. *Climacteric* 2010;13:509-522.
- Hummelen R, Macklaim JM, Bisanz JE, et al. Vaginal microbiome and epithelial gene array in post-menopausal women with moderate to severe dryness. *PLoS One* 2011;6:e26602.
- Brotman RM, Shardell MD, Gajer P, et al. Association between the vaginal microbiota, menopause status, and signs of vulvovaginal atrophy. *Menopause* 2014;21:450-458.
- Pabich WL, Fihn SD, Stamm WE, Scholes D, Boyko EJ, Gupta K. Prevalence and determinants of vaginal flora alterations in postmenopausal women. *J Infect Dis* 2003;188:1054-1058.
- Mitchell CM, Srinivasan S, Zhan X, et al. Vaginal microbiota and genitourinary menopausal symptoms: a cross-sectional analysis. *Menopause* 2017;24:1160-1166.
- Gaydos CA, Beqaj S, Schwebke JR, et al. Clinical validation of a test for the diagnosis of vaginitis. *Obstet Gynecol* 2017;130:181-189.
- Hilbert DW, Smith WL, Chadwick SG, et al. Development and validation of a highly accurate quantitative real-time PCR assay for diagnosis of bacterial vaginosis. *J Clin Microbiol* 2016;54:1017-1024.
- Fredricks DN, Fiedler TL, Thomas KK, Oakley BB, Marrazzo JM. Targeted PCR for detection of vaginal bacteria associated with bacterial vaginosis. *J Clin Microbiol* 2007;45:3270-3276.
- Cartwright CP, Pherson AJ, Harris AB, Clancey MS, Nye MB. Multi-center study establishing the clinical validity of a nucleic-acid amplification-based assay for the diagnosis of bacterial vaginosis. *Diagn Microbiol Infect Dis* 2018;92:173-178.
- Cartwright CP, Lembke BD, Ramachandran K, et al. Development and validation of a semiquantitative, multitarget PCR assay for diagnosis of bacterial vaginosis. *J Clin Microbiol* 2012;50:2321-2329.
- Dols JAM, Smit PW, Kort R, et al. Microarray-based identification of clinically relevant vaginal bacteria in relation to bacterial vaginosis. *Am J Obstet Gynecol* 2011;204:305.e1-305.e7.
- Portman DJ, Gass ML; Vulvovaginal Atrophy Terminology Consensus Conference P. Genitourinary syndrome of menopause: new terminology for vulvovaginal atrophy from the International Society for the Study of Women's Sexual Health and The North American Menopause Society. *Menopause* 2014;21:1063-1068.
- Menard J, Fenollar F, Henry M, Bretelle F, Raoult D. Molecular quantification of *Gardnerella vaginalis* and *Atopobium vaginae* loads to predict bacterial vaginosis. *Clin Infect Dis* 2008;47:33-43.
- Shipitsyna E, Roos A, Dattu R, et al. Composition of the vaginal microbiota in women of reproductive age: sensitive and specific molecular diagnosis of bacterial vaginosis is possible? *PLoS One* 2013; 8:e60670.
- Kawa D, Paradis S, Yu J, LeJeune M. Elevating the standard of care for women's health: The BD Max Vaginal Panel and management of vaginal infections. Available at: <https://moleculardiagnosics.bd.com/wp-content/uploads/2017/08/MAX-Vaginal-Panel-Whitepaper.pdf>. Accessed February 3, 2020.
- Hillier SL, Lau RJ. Vaginal microflora in postmenopausal women who have not received estrogen replacement therapy. *Clin Infect Dis* 1997;25 Suppl 2:S123-S126.
- Gutman RE, Peipert JF, Weitzen S, Blume J. Evaluation of clinical methods for diagnosing bacterial vaginosis. *Obstet Gynecol* 2005;105: 551-556.
- Schwebke JR, Gaydos CA, Nyirjesy P, Paradis S, Kods S, Cooper CK. Diagnostic performance of a molecular test versus clinician assessment of vaginitis. *J Clin Microbiol* 2018;56:pii: e00252-18.
- Heinemann C, Reid G. Vaginal microbial diversity among postmenopausal women with and without hormone replacement therapy. *Can J Microbiol* 2005;51:777-781.