

Vaginal pH Value in Common Vaginitis

Subjects: Obstetrics & Gynaecology

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In modern society, 75% of all women worldwide have had vaginitis at least once in their lives. The vagina has a dynamic microbial ecosystem with varying vaginal pH levels. An imbalance in that ecosystem can alter the vaginal pH and tip the scale to the point of causing issues, such as vaginitis, that require medical attention. Although vaginitis is not an incurable disease, it causes discomfort and pain that disrupt women's daily lives. The most common causes of vaginitis include bacterial vaginosis, trichomoniasis, and vulvovaginal candidiasis. In this review, we discuss the causes, diagnostic methods, and symptoms of different types of vaginitis, the relationship of vaginitis to the prevalence of other diseases, issues associated with recurrent vaginitis and the immune system, and a variety of effective available treatments.

Keywords: vaginal pH ; vaginitis ; diagnosis ; treatment

1. Introduction

The vagina serves as an outside-communicating channel with the functions of draining menstruation and childbirth delivery. The vagina normally has unique flora that sustains the internal physical and chemical environment. The presence of normal flora relies on maintenance of various components of the ecosystem, which is in dynamic equilibrium ^[1]. Based on several published articles, the normal vaginal pH for women of childbearing age ranges from 3.8 to 5.0, which is moderately acidic ^{[2][3]}. The normal vagina is covered by a thin layer of transparent liquid, commonly known as vaginal fluid. Many factors may lead to changes or imbalances in the vaginal pH value, including vaginal infections, aging, sexual activity, and vaginal douching ^[4].

The common vaginal microbiome, the *Lactobacilli* species, can produce acidic pH and bacteriocins to kill other bacteria in the vagina. *Lactobacilli* can produce an acidic environment in the vagina, which is designed to protect women from sexually transmitted pathogens and opportunistic infections ^[5]. If these normal flora such as *Lactobacilli* are absent or significantly reduced, the vaginal ecosystem will become imbalanced, and other microorganism or bacteria inside vagina may become overgrown, leading to vaginitis. Moreover, Ravel et al. first identified the five community state types (CSTs) in 2011 ^[6], providing a powerful scheme to classify the status of the human vaginal microbial community (HVMC). These communities are divided into five groups: four groups are dominated by *Lactobacillus iners*, *L. crispatus*, *L. gasseri*, or *L. jensenii*, and the fifth has a lower proportion of lactic acid bacteria and a higher proportion of strictly anaerobic organisms.

Vaginitis has different types, including bacterial vaginosis (BV), vaginal candidiasis, trichomoniasis, and aerobic vaginitis ^[7]. This review focuses on the first three common types of vaginitis. Under the current standard, the diagnosis of vaginitis depends on criteria based on several clinical presentations. For example, the diagnosis of bacterial vaginosis has been based on Amsel Criteria in clinical ^[1] routine since 1983. Following the Amsel Criteria, bacterial vaginosis is diagnosed by the presence of three out of four conditions, including homogenously milky vaginal discharge, vaginal pH over 4.5, positive KOH whiff test, and 20% at least of clue cells under wet-mount test by microscope ^[8]. The Nugent Score is a scoring system that calculates the relative number of bacterial morphologies under Gram-stained vaginal discharge smears to diagnose bacterial vaginosis ^[9]. For both abovementioned diagnostic criteria, the vaginal fluid pH is a useful and unique marker for vaginitis. Abnormal pH values increase the possibility of vaginitis, and the measurement of vaginal pH has been used for initial screening ^[10]. From previous studies, a vaginal fluid pH value of 4–4.5 or less signifies the absence of vaginitis, whereas a pH value of more than 4.5 denotes vaginitis and bacterial vaginosis (BV) ^[11]. However, with a trichomonas vaginalis infection, the pH value may be increased to 6.5 or more ^[12].

There are various signs and symptoms of vaginitis that hint at different types of vaginitis with further corresponding treatments in clinical routine. In previous research, a combination test of vaginal fluid pH value with symptomology was shown to diagnostic sensitivity ^[13]. **Table 1** and **Table 2** demonstrate the associated symptoms, signs, risk factors, and treatments of different types of vaginitis ^{[12][13][14][15][16][17]}. From this article, we review the relationship among vaginitis, vaginal fluid pH, and the associated immune system. In the closing discussion, we also review the use of commercially available vaginal pH testing products. These vaginal fluid pH test products can serve as self-test tools used at home by

patients themselves, especially those with suspected symptoms of vaginitis, such as unusual odor, itching, burning pain, or abnormal vaginal fluid. We hope that this study can increase women’s attention to vaginitis and encourage women to seek treatment as early as possible.

Table 1. Symptoms and signs of vaginitis (Information from [12][13][14][15][16][17]).

Diagnosis	Etiology	Symptoms	Signs	Risks	pH Value
Bacterial vaginosis	Anaerobic bacteria (Prevotella, Mobiluncus, Gardnerella vaginalis, Ureaplasma, Mycoplasma)	Fishy odor; malodorous; homogenous; clear, white, or gray discharge that may worsen after intercourse; pelvic discomfort may be present.	No inflammation.	Increased risk of HIV, gonorrhea, chlamydia, and herpes infections.	greater than 4.5
Vulvovaginal candidiasis	Candida albicans, Candida krusei, Candida glabrata	No odor; white, thick, cheesy, or curdy discharge; vulvar itching or burning.	Signs of inflammation; Vulvar erythema and edema.	vulvodynia	4.0
Trichomoniasis	Trichomonas vaginalis	Green or yellow, frothy discharge; foul odor; pain with sexual intercourse, vaginal soreness, dysuria.	Signs of inflammation, “strawberry cervix”; Vestibular erythema may be present.	Increased risk of HIV infection Increased risk of preterm labor. Should be screened for other sexually transmitted infections.	5.0–6.0

Table 2. Treatment for the most common vaginitis (Information from [13][14][15][18]).

Treatment		
	Initial Regimen	Alternative Regimen
Bacterial vaginosis	Metronidazole (Flagyl), 500 mg orally twice daily for seven days Or Metronidazole 0.75% gel (Metrogel), one full applicator (5 g) intravaginally daily for five days Or Clindamycin 2% cream, one full applicator (5 g) intravaginally at bedtime for seven days	Tinidazole (Tindamax), 2 g orally once daily for two days or Tinidazole, 1 g orally once daily for five days Or Clindamycin, 300 mg orally twice daily for seven days or Clindamycin (Cleocin Ovules), 100 mg intra-vaginally at bedtime for three days
Vulvovaginal candidiasis	Topical azole therapy or Fluconazole (Diflucan), 150 mg orally, single dose	Medical-grade honey (MGH)
Trichomoniasis	Metronidazole, 2 g orally, single or divided dose on the same day Or Tinidazole, 2 g orally, single dose	Metronidazole, 500 mg orally twice daily for seven days

2. The Role of Normal Vaginal pH

The pH level associated with the vagina is called the “vaginal pH value,” and it plays a valuable role in determining vaginal health. The acidic and/or alkaline state are determined by the scale of hydrogen ion activity and measured with the pH value. The naturally neutral pH is equal to 7, but the normal vaginal pH ranges between 3.8 and 5.0, which is moderately acidic [2]. A lower pH value (more acidic) in the vagina than the blood or interstitial fluids can protect vaginal mucosa from pathogenic organisms [4]. The vaginal pH can be affected by overall health conditions, including age, vaginal hydration status, daily diet, and safe intercourse. The vaginal pH value is age-dependent. The normal vaginal pH value for a woman of reproductive age ranges from 4.0 to 4.5, but the value may be slightly higher than 4.5 among premenarchal and postmenopausal women [12].

The vaginal pH value clearly plays an important role in vaginal health, but it is important to note that maintaining a healthy vaginal pH is characterized by the metabolism of *Lactobacillus acidophilus* and other endogenous flora, estrogen, glycogen, and existing flora and pathogens. There is a dynamic relationship between the by-products [16]. Vaginal microorganisms are the primary stabilizers of the vaginal ecosystem. Of those microorganisms, *Lactobacillus acidophilus* is the primary player. This particular microorganism can ferment glycogen derived from the decay of eutrophic

vagina mucosa into lactic acid and subsequently release hydrogen ions ^[19]. The result of this metabolism is an acidic pH of 4–4.5, and the resulting acidic vaginal environment provides a protective effect. It creates a barrier that prevents unhealthy microbiome from multiplying too quickly and causing infection. The imbalance in this ecosystem can cause an unusual vaginal pH and may be used to determine the presence of bacterial pathogens as well as menopausal status ^[20]. In addition, studies have confirmed that an increase in vaginal pH may lead to bacterial vaginosis (BV) and spontaneous preterm deliveries (PD) in pregnant women ^[21]. Based on the above research, we know that vaginal pH value has a profound impact on women's lives. Monitoring that pH level, even with self-testing, can be used to effectively manage and prevent infection.

Factors That Cause Imbalances in the Vaginal pH

In a woman's daily life, there are many factors that can cause normal vaginal pH value to become unbalanced, such as unprotected sex, taking antibiotics, vaginal douching, and variations in the menstrual cycle.

Unprotected sexual behavior can lead to an unbalanced vaginal pH ^[22]. The semen is relatively alkaline, with a pH value of approximately 8.0. and can alter the vaginal pH during unprotected intercourse. Semen can trigger the growth of bacteria that can act as a physiological buffer ^[23]. Thus, unprotected sex can significantly alter the vaginal pH so that it remains elevated even after 10–14 h ^[24]. This alteration leaves the vagina less protected against infection.

Antibiotics can inhibit bacterial growth or kill bacteria to treat bacterial infections ^[25]. In clinical routine, antibiotics are frequently used to treat vaginitis ^{[25][26]}. Unfortunately, the antibiotics that kill harmful bacteria also kill good bacteria that maintain a healthy, more acidic vaginal pH value. However, for patients with severe symptoms, antibiotics are still necessary. Antibiotics can rapidly alter the vaginal microbiome within a few hours ^[27].

Under normal circumstances, the vagina has a self-cleaning function. It does not require any special procedures or solutions beyond normal bathing with clean water. Excessive cleaning or douching of the vagina can not only rinse away vaginal secretion, but can also create an unbalanced vaginal flora with an abnormal vaginal pH environment. Such impaired ecosystem of vagina can cause adverse effects, including BV, pelvic inflammatory disease (PID), pregnancy complications, and even cervical cancer ^{[28][29][30][31]}. Thus, the risks of vaginal lavage are far greater than the benefits.

Women's menstrual cycles are strictly controlled by endocrine, autocrine, and paracrine factors that modulate the endometrial remodeling and regulate the follicular development, ovulation, and luteinization of the ovary ^[32]. During menstruation, a large amount of menstrual blood flows through the vagina and is absorbed into a tampon or pad and sits in place. The menstrual blood is slightly alkaline and can cause the vaginal pH to rise. Menstrual cycle disorders caused by hormonal imbalance, in addition to the abovementioned abnormal menstrual blood, will also cause vaginal mucosal disorders, which, in turn, affects the microbial microenvironment and causes an increase in vaginitis ^[33]. For women with a normal, active menstruation cycle, the vaginal pH is typically between 3.8 and 5.0 ^[3]. Abnormal menstrual cycles are a common feature of puberty. Their existence is related to an increased risk of abnormal pH. The subsequently relatively high vaginal pH may also result in susceptibility to BV ^[34].

3. Vaginal pH Test Products





If women experience abnormal vaginal symptoms such as itching, burning, unpleasant vaginal odor, or abnormal vaginal discharge, then they may need to test their vaginal pH. However, the U.S. Food and Drug Administration (FDA) notes that women should understand that at-home tests will not help diagnose HIV, chlamydia, herpes, gonorrhea, syphilis, or group B streptococcus ^[35]. It is clear that clinicians already use vaginal pH testing to help diagnose the causes of vaginitis ^{[8][20]}. With the increasing demand for self-diagnosis and self-treatment, pH tests allow women to self-manage some of their health care. This review details the use of such self-test tools for screening purposes and recommends their use as a rapid, simple, and effective early screening tool.

The Hygeia Touch Self-Testing Kit for Vaginal Infection ^[36] (Hygeia Touch Inc., Taipei, Taiwan; MHW Medical Device Manufacturing No. 006714) uses a vaginal applicator that includes a bromocresol green pH indicator embedded into a biocompatible grip. This test stick is assembled from a pH test paper and a biocompatible plastic stick. This tool is inserted into the vagina to collect a sample, and then allowed to rest for 1 min to allow the secretions to react with the pH test paper. Colorimetric results indicate pH level and can help distinguish the cause of infection, i.e., *Candida albicans*, bacteria, or trichomonas. Furthermore, this device has been registered with the U.S. FDA.

Another product on the market, the Biosynex Exacto 3 vaginal infection test ^[37], has demonstrated reliability and accuracy (90%). It is easy to use, can produce immediate results, and is suitable for the preliminary diagnosis of vaginal infection.

This product provides straightforward vaginal contact sampling and presents rapid, easy-to-interpret, and simple color-coded results. There are several other commercially available vaginitis self-diagnostic devices summarized in **Table 3**.

Table 3. Summary of commercially available vaginal self-test products.

Brand	Hygeia Touch	Biosynex	FloriSense	Monistat
Appearance				
Accuracy	88%	90%	92%	92%
Test/pack	1	3	2	2
Advantage	The double-layer structure is optimized for product safety and ease of use.	Because there are 3 tests in each box, there is an advantage in quantity.	Reliable accuracy is over 90% and product is easy to read.	Effective for the diagnosis of yeast-based vaginal infections

Among all available products, The Hygeia Touch Self-Testing Kit for Vaginal Infection has a distinct advantage. The double-layer protection design prevents the test paper from falling off and not directly touching the skin, and the elastic baffle design ensures that the depth of insertion is not overly deep. The use of flexible, medical-grade plastic makes it comfortable and safe for use. The appropriate use of these devices allows patients to monitor the disease course and select the correct over-the-counter (OTC) antifungal drugs, which the FDA approved in 1990. These products can be used by patients themselves, enhance the caution of vaginal health, and facilitate the maintenance of vaginal pH and overall health.

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