Role of pH of External Auditory Canal in Acute Otitis Externa

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Received: 29 August 2013 / Accepted: 14 October 2013 / Published online: 24 October 2013
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Abstract Prospective and interventional. We studied the pH of external auditory canal (EAC) in normal individuals and patients with acute otitis externa (AOE), its variation with change of temperature and humidity, different symptoms and number of symptoms at presentation (Day 0) and various stages of treatment in 100 normal ears and forearms and 50 ears having AOE. The mean pH of normal EAC was 3.950 ± 1.199 while that of forearm was 4.775 ± 0.910 . There was increase in the number of patients with increase in relative humidity, however, the change in the pH of EAC was statistically not significant ($p > 0.05$). Significant fall in pH was observed at 1 and 2 weeks of treatment. The normal EAC pH is relatively more acidic as compared to that of forearm skin and it became more alkaline in cases of AOE with reversion back to acidic pH after treatment. Acidification of the EAC is the only treatment required in most cases. No significant change in pH of ears was observed with changes of temperatures and humidity.

Keywords External otitis · pH · Otitis externa · Acetic acid

Introduction

Acute otitis externa (AOE) refers to inflammation and infection of the skin and subcutaneous tissue of the external auditory canal (EAC). The characteristic symptoms include itching, pain, aural fullness and hearing loss. The tragal tenderness is definitive diagnostic sign. Clinical examination typically reveals erythema and edema of the external canal skin, which may spread to involve the concha and lobule. Seropurulent otorrhoea often results in crusting of the EAC and concha. The manipulation of the tragus/pinna and mastication generally elicit pain. In advanced cases, worsening edema significantly narrows the external canal, preventing visualization of the tympanic membrane and associated inflammatory changes may spread to involve preauricular soft tissue [1].

Cerumen plays an important protective role in EAC physiology. A relatively acidic pH and hydrophobic nature account for its bacteriostatic properties [1]. A warm, moist environment favours bacterial growth, and is responsible for the increased incidence of acute otitis externa during summer months and in regions with tropical climates.

During the summer months in temperate climates and particularly during the monsoon in India more cases of otitis externa are seen. Acute otitis externa affects ~4 of every 1,000 children and adults per year [2, 3]. Approximately 10 % of people will suffer from AOE at some point in their lifetime [4]. It usually occurs unilaterally, however, may affect both ears in 10 % of cases [3].

Fabricant and Perlstein [4], in 1949, were the first otologists to develop an interest in skin pH of EAC of

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normal cases/persons/subjects. Fabricant [5], in 1957, compared his initial findings with the pH of individuals affected by acute otitis externa. However, it was coarse from viewpoint of today's standard. In 2003, Martinez-Devesa et al. [6] studied pH in chronic cases of otitis externa with an age/sex matched control group, whereas van Balen et al. [7] compared the clinical efficacy of three common treatments in acute otitis externa, viz. ear drops containing either acetic acid, acetic acid with corticosteroid or corticosteroid with antibiotic. Recently, Kim and Cho [8] deliberated correlation between the degree of AOE and change of pH after acidification compared to an antibiotic otic solution. Nevertheless, literature on the subject of pH in cases of AOE is sparse. The change of pH of EAC in causation and pathogenesis of AOE in our set-up remains mostly uninvestigated.

The present work attempts to study the pH of external auditory canal in cases of acute otitis externa and compare it with the pH of normal ears as well as hair bearing area of the body i.e. forearm. The variation of the pH in external auditory canal with respect to the changes in the season (temperature/humidity) was studied. Moreover, the effect of different symptoms and the number of symptoms at presentation (Day 0) on the pH of EAC in AOE was also studied. Lastly, the changes of pH of EAC with treatment were deliberated in detail.

Materials and Methods

This was a prospective and observational study conducted from November, 2010 to April, 2012 at Department of Otorhinolaryngology-Head and Neck Surgery, Lady Hardinge Medical College, New Delhi.

Patients

Fifty cases of acute otitis externa (50 ears) between 18 and 70 years age group were inducted in the study. Randomly, age-matched 50 normal subjects (100 ears not suffering from any disease) were included as controls. The diagnostic criteria were rapid onset of symptoms such as otalgia, itching, or fullness and signs such as canal edema, erythema, or otorrhoea having tragal tenderness. Cases of acute suppurative otitis media (ASOM) and chronic suppurative otitis media (CSOM), chronic otitis externa, malignant otitis externa, furunculosis, allergic otitis externa, contact dermatitis, psoriasis, systemic dermatitides and granular otitis externa, and cases with systemic diseases like diabetes, immunodeficiency and patients on immunosuppressive drugs/cancer chemotherapy were excluded from the study. Cases of acute otitis externa having treatment elsewhere at presentation were also excluded.

Methods

After taking detailed history of all the patients with acute otitis externa, the patients were subjected to thorough otorhinolaryngological examination. Systemic examination was also done to rule out any systemic disorder. This was followed by the measurement of the pH of the external auditory canal by placing the probe in the outer third of the external auditory canal maintaining contact with the posterior canal wall till the constant value was obtained with the device (Gastrograph Mark IV, SME Medizintechnik, GmbH, Germany), according to the method of Martinez-Devesa et al. [6]. Concurrently, the pH of the surface of skin of the right forearm (hair bearing area of the body) was also measured and recorded in all cases.

The patients were subjected to measurement of the pH of the external auditory canal three times during the study, first at the time of presentation in OPD (day 0), second time after one week (day 7) of treatment and third after 2 weeks (day 14) of treatment. All patients were treated with topical otic solution containing neomycin/clotrimazole (pH 3.7) 5–8 drops thrice daily and oral analgesic drugs (Tab. paracetamol 500 mg thrice daily for 3 days and SOS). In severe cases antimicrobials [tab. Augmentin (45 mg/kg in three divided doses)] were prescribed for 5 days along with glycerine ichthammol ear packing (changed daily). The patients were followed up at weekly interval for 2 weeks after initiation of the treatment and the response to the therapy and change in the pH of external auditory canal was recorded.

The monthly average temperature and average relative humidity of New Delhi was taken from the official website of India Meteorological Department, Regional Meteorological Centre, New Delhi [9].

Statistical Analysis

The mean pH values of normal EAC, normal skin, and diseased ears at day 0, 7, and 14 were calculated. The correlation between pH values and temperature and humidity was analysed using Pearson correlation. Moreover, the variation in the pH with change of temperature and humidity was analysed using ANOVA test. The mean pH of normal ear and diseased ear at time of presentation (day 0) was compared using independent student *t* test. The mean pH of the diseased ear during follow-up (day 7 and 14) was analysed using paired student *t* test. Independent student *t* test was used to compare the pH of diseased ear with different symptom presentations. Pearson correlation was calculated with mean pH at presentation and the number of symptoms at presentation. Calculations were performed with IBM SPSS Statistics version 20.

Results

The male-to-female ratio in patient group was 1:1 whereas in control group was 3:2. The mean age of male patients was 29.44 years, and that of female patients was 30.60 years.

Mean pH of Normal EAC Versus Hair Bearing Area of Body

The mean pH of the forearm was 4.775 ± 0.910 , while the mean value of pH of the normal EAC was 3.950 ± 1.199 . The difference in the pH of the body and that of the normal EAC was significant ($p = 0.000$).

Comparison of pH of Normal EAC with pH of EAC in AOE

The mean pH of EAC at presentation was 5.606 ± 1.629 while that of normal EAC was 3.950 ± 1.199 indicating significantly higher pH in the diseased ears (i.e. pH of the EAC became more alkaline in acute otitis externa as compared to the normal ears). Moreover, the change in pH of the EAC in AOE is statistically significant ($p = 0.000$; Table 1).

Comparison of pH of Diseased EAC with Different Presentations

Pain was the common presentation amongst all (100 %) the patients of acute otitis externa. Aural fullness and decreased hearing was present in 46 % of patients while otorrhea was present in 32 % of the cases. However, itching was the least common presentation accounting for only 24 % of all cases of acute otitis externa. Since pain was the common presentation among all the subjects of case group, its effect on the mean pH of the EAC could not be calculated.

There was change in mean pH of EAC with presence or absence of itching, otorrhea, aural fullness and decreased hearing. The mean pH of the EAC with presence of itching was 5.517 ± 1.600 whereas the pH in absence of itching was 5.634 ± 1.658 . While in the presence of the ear discharge the mean pH of the EAC was 6.412 ± 1.193 , the mean pH in the absence of otorrhea was 5.227 ± 1.682 . It was observed that the presence of symptoms like aural fullness and decreased hearing had a similar effect on the

mean pH of the diseased ear. The mean pH of the ear in the presence of these symptoms was 6.213 ± 1.417 whereas in the absence it was found to be 5.089 ± 1.643 . Therefore, the change in the mean pH of the diseased EAC was significant with the presence of otorrhea, aural fullness and decreased hearing. However, the change in mean pH with presence of itching was not statistically significant (Table 2).

Correlation of pH of Diseased Ear with Number of Symptoms at Presentation

As evident from the Table 3, the pH of the diseased ear varied with the number of symptoms at the time of presentation. As the number of symptoms increased, the mean pH changed from 5.185 ± 1.790 when there was single symptom to 6.542 ± 1.297 when the number of symptoms at presentation was four. Change in the mean pH with increasing number of presentations was found to be significant ($p < 0.05$). However, the effect of temperature and relative humidity on the change of mean pH of diseased ear was found to be insignificant ($p > 0.05$).

Mean pH of Diseased EAC at Various Stages of Follow-up

The mean pH of the diseased EAC after 1 week of treatment was 4.792 ± 1.166 whereas mean pH after 2 weeks of treatment was 4.410 ± 0.962 . The paired *t* test analysis of mean pH of diseased EAC at Day 0, 7 and 14 showed fall of pH of the EAC during the course of treatment. The fall in the mean pH of the diseased EAC between day 0 and day 7 was 0.814 ± 0.463 whereas the fall of mean pH between day 7 and day 14 was 0.382 ± 0.203 (Fig. 1). The overall fall in the mean pH between day 0 and day 14 was 1.196 ± 0.666 . Moreover, the fall in the mean pH during the course of treatment was found to be statistically significant ($p = 0.000$) i.e. pH became more acidic as shown in Table 4.

Monthly Number of Cases and Variation of pH of Normal EAC and Forearm with Changes in Temperature and Humidity

The maximum average temperature in New Delhi was recorded during the month of May and June whereas the highest average relative humidity was observed in months

Table 1 Comparison of pH of normal EAC with pH of EAC in AOE

	Group	<i>n</i>	Mean	Std. deviation	<i>p</i> value
pH value	Normal ear	100	3.9500	1.19937	0.000
	Diseased ear	50	5.6060	1.62887	

Table 2 Comparison of pH of diseased EAC with different presentations

	<i>n</i>	Mean	Std. deviation	<i>p</i> value
Itching				
pH of diseased ear (Day 0)				
Absent	38	5.6342	1.65811	0.830
Present	12	5.5167	1.59991	
Otorrhea				
pH of diseased ear (Day 0)				
Absent	34	5.2265	1.68187	0.015
Present	16	6.4125	1.19324	
Aural fullness/decreased hearing				
pH of diseased ear (Day 0)				
Absent	27	5.0889	1.64348	0.012
Present	23	6.2130	1.41560	

Table 3 Correlation of pH of diseased ear with number of symptoms at presentation

No. of presenting Complaints	<i>n</i>	Mean	Std. deviation	<i>p</i> value
pH of diseased ear (Day 0)				
1	20	5.1850	1.79041	0.021
2	7	4.8143	1.19782	
3	3	4.4000	0.78102	
4	19	6.5421	1.29714	
5	1	5.4000	–	
Total	50	5.6060	1.62887	

Fig. 1 Mean pH of diseased EAC at various stages of follow-up **Table 4** Paired analysis of mean pH at different stages of follow-up

		<i>p</i> value
Pair 1	pH of diseased ear (Day 0)–pH of diseased ear (Day 7)	0.000
Pair 2	pH of diseased ear (Day 0)–pH of diseased ear (Day 14)	0.000
Pair 3	pH of diseased ear (Day 7)–pH of diseased ear (Day 14)	0.000

of August and September. Moreover, the maximum number of cases of acute otitis externa presented during the time of high relative humidity, 15 patients presented in September when the average relative humidity was 69 %

whereas 11 patients presented in August when the relative humidity was 73 %. However, increase in the average maximum temperature was not associated with increase in the number of cases of acute otitis externa (Fig. 2)

Fig. 2 Monthly number of cases, average temperatures and humidity

Table 5 Variation in the pH of normal EAC and forearm with changes in seasons (temperature and humidity)

		Average temperature (celsius)	Average relative humidity (%)
pH of forearm	Pearson correlation	0.020	−0.064
	Sig. (2-tailed)	0.841	0.528
pH of normal ear	Pearson correlation	0.067	0.037
	Sig. (2-tailed)	0.511	0.715
pH of normal ear	Pearson correlation	0.042	0.071
pH of forearm	Sig. (2-tailed)	0.675	0.484

The correlation between the pH values of normal EAC and forearm with changes in temperature and humidity was analysed. However, the change in pH of both the EAC and the skin of body showed positive correlation with the temperature and humidity, yet the correlation between the two is insignificant ($p > 0.05$; Table 5).

Discussion

In this study, we observed that the pH of the normal EAC was acidic as compared to that of the body and it became more alkaline in acute otitis externa. The number of cases increased in the months with high relative humidity but the correlation between the pH of EAC with the change in season was not statistically significant. It was also noted that the pH of EAC in AOE at presentation was highest in

cases with otorrhea followed by cases with aural fullness and decreased hearing. Change of pH with presence of itching was not significant. Moreover, the pH of the EAC became relatively more alkaline when the number of symptoms at presentation increased from one to five. Lastly, we established that the treatment of the condition was associated with restoration of pH of EAC back to normalcy.

Superficial skin acidity reinforces the bactericidal function of skin. This hypothesis was postulated in late 1930s by dermatologists who thought that skin was covered by an acid cloak [10]. Fabricant [5], in 1957, was the first otolaryngologist who found that AOE was related to a loss of acidity. However, his study did not reach the appropriate level of evidence. Martinez-Devesa et al. [6] showed a very close correlation between the severity grade of chronic otitis externa (COE) and the pH of the EAC.

Acute otitis externa differs from COE in several respects [2, 3]. First, the duration of AOE never exceeds 3 months, whereas that of COE always exceeds 3 months. Second, AOE is primarily of bacterial origin, whereas COE is commonly of fungal or allergic origin. AOE is accompanied by symptoms and signs such as severe pain, otorrhea, pruritus, and conductive hearing loss, whereas COE is usually characterised by pruritus, mild discomfort and erythema of the EAC. Therefore, the changes in the pH in AOE could be different from that in COE. Our results are nearly in agreement with the results found in COE.

Kim and Cho [8], in 2009, studied the variation of the pH of EAC in AOE relative to severity of disease and the recovery of pH after acidification and concluded that EAC lost its acidity proportionately to the severity of disease and both vinegar irrigation and topical antibiotics were equally effective for the restoration of pH. Hence, the hypothesis that ear canal pH has a bearing on otitis externa has been strengthened by the results of the present study.

Conclusions

Our observations suggest that mean pH of normal EAC is significantly more acidic as compared to pH of the forearm skin. It also revealed relative alkalinity (higher pH) of the ears suffering from AOE as compared to normal ears. This study is first to demonstrate that the pH of the diseased ear varied significantly with different symptoms and number of symptoms at presentation (Day 0). Reversion of the pH of ear to acidic as the disease resolved was also observed.

However, we did not find any change, statistically significant, in the pH of the ears with change in temperatures and relative humidity.

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