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CLINICAL STUDY

Climatic influence on conjunctival bacteria of patients undergoing cataract surgery

EF Rubio

Abstract

Purpose **To describe the monthly prevalence of conjunctival bacteria in patients undergoing cataract extraction and the possible climatic influence on it, in Madrid, in order to clarify postsurgical endophthalmitis pathogenesis.**

Methods **The lower conjunctival content sample of 4432 consecutive patients awaiting cataract surgery was cultured from January 1994 to December 1996. The dates of the operations and the rehospitalization for postsurgical endophthalmitis, if this took place, were checked. The isolated bacteria were grouped to study the statistical significance of the differences in the monthly prevalence differences (χ^2 tests). Temperature and relative humidity are given monthly for the area where our patients live.**

Results **The total frequency of the conjunctival bacteria increases in April, May, and June, when the daily average temperature rises from 12 to 22°C and the relative humidity oscillates between 45 and 60% in our area. Bacteria groups' frequency was significantly higher as follows: Staphylococci coagulase negative (>60%) in April, May, and June; *Corynebacterium* sp (>33%), *Staphylococcus Aureus* (>8%), and other Gram-positive bacteria (>2.5%) in May; *Streptococcus Pneumoniae* increases (>3.4%) in March, November, and December; *Haemophilus* sp (>3.4%) in January and April; Gram-negative Cocci (>3%) in April; and other *Streptococcus* sp (>6%) in April, May, and September. Our incidence of rehospitalization for endophthalmitis after cataract extraction in May and June together was 3.37 times higher than in the other months.**

Conclusion **Conjunctival bacteria of our patients undergoing cataract surgery present a seasonal prevalence pattern, which could be considered as a predisposing condition for having postsurgical endophthalmitis in certain months.**

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Introduction

In a recent study in Switzerland, an increased incidence of postsurgical endophthalmitis (PE) after cataract extraction in April, May, and June was attributed to climatic factors.[1] Also in the same period, in Scotland,[2] a hospital infection control team reported more acute PE than expected after cataract surgery, according to the normal incidence.[3]

Among the many risk factors involved in the PE pathogenesis,[4–11] it is difficult to assess the weight of climatic influence; however, as conjunctival bacteria are the main source of contamination in cataract surgery,[12,13] it is quite logical to expect that the prevalence of conjunctival bacteria determines the prevalence of the infectious PE. Today, the world-wide use of povidona iodine solution as a preoperative prophylaxis in cataract extraction[14] could provide homogeneity in the kind of bacteria that produce PE all over the world, which was impossible to detect when a great number of different prophylactic techniques were used.[15,16]

On the other hand, it is well known that climatic factors determine the incidence of conjunctivitis over the year in many parts of the world;[17] it is worth mentioning the study of the seasonal pattern of conjunctivitis in London,[18] which describes the responsible bacteria month

Ophthalmic Institute Laboratory
Department of Ophthalmology
'Gregorio Marañon' University General Hospital
Madrid, Spain

Correspondence: EF Rubio
c/Vizconde de los Asilos 12, 2° B 28027 Madrid
Spain
Tel: +34 91 5867326
Fax: +34 91 7423586
E-mail: elfernan@wol.es

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by month. These data suggest the possibility of some patients undergoing cataract surgery being affected spontaneously by conjunctivitis due to climatic influence.

Herein, the monthly prevalence of conjunctival bacteria in a large sample of patients awaiting cataract surgery is studied, in order to consider if climatic influence would be another risk factor for having infectious PE after such operations, which could help to understand the pathogenesis of this serious infection, and perhaps to improve its prevention.

Materials and methods

Study design

A retrospective prevalence study was performed using the routine preoperative conjunctival culture of every patient awaiting cataract extraction in the Ophthalmic Institute of the Gregorio Marañon University General Hospital, in Madrid. The preoperative conjunctival bacteria of 4432 consecutive patients, cultured from January 1994 to December 1996, has been recorded in a database DB3 Plus (one record per patient) in Ophthalmic Institute Laboratory.

At least a year after the cataract extraction, it has been confirmed by means of the hospital-computerized codes for diagnoses and surgical procedures from the International Classification of Diseases: Ninth revision[19] that every patient from our laboratory database had been operated on, and the date of the surgery had been recorded; at the same time, the date of the rehospitalization for PE was recorded if it took place. Every medical record of a patient rehospitalized for PE was examined, retrospectively, to check, among other things, if the affected eye was that operated on for cataract extraction. No patients had been excluded from the planned surgery for any pre-existing conditions and all of them were advised not to use any antibiotic eye drops during the 48 h before taking the conjunctival sample, and not to wash the eyes that day, before taking the sample in the early morning. The age of the patients ranged from 3 to 97, the average being 71 ± 11 and 53% of them being women.

The climatic characteristics of the 3-year study period were obtained from the Spanish National Institute of Meteorology, by means of an official request. The data correspond to the Retiro Station, the nearest meteorological station to where our patients live, next to our Hospital. The two climatic variables, temperature and relative humidity, have been chosen because of being statistically associated with the monthly conjunctivitis incidence in Madrid.[20] It is collected in addition to the monthly average of the same data in the period 1971–2000 published by the National Institute of Meteorology in a guide;[21] in this guide[21] other meteorological data are available, in case Ophthalmologists elsewhere would like to compare the climatic characteristics of their areas.

Microbiological method

The technique used to obtain the conjunctival flora consists of taking a sample of the content of the lower conjunctiva sac with a microlitre platinum loop and spreading it on each of the three culture media used (blood-Agar, chocolate-Agar supplemented with *polivitex* and MacConkey-Agar). We use one plate for each patient, with an eye sample on each half-plate. The media were incubated for 48 h; to the chocolate-Agar 10% of CO_2 was added. The identification of the isolated bacteria was made following the procedures described in the Manual of Clinical Microbiology.[22]

The isolated bacteria were grouped into nine categories, two of nonpathogen flora (Staphylococci coagulase negative and *Corynebacterium* sp), and seven of pathogen flora (*Staphylococcus Aureus, Streptococcus Pneumoniae*, other *Streptococcus* sp, *Haemophilus* sp, other Gram-negative rods, Gram-negative cocci, and other Gram-positive bacteria). The bacteria of all nine categories were tabulated, grouping together the same month for each of the 3 years, in order to obtain enough quantities of the scarce bacteria to allow statistical calculations.

Statistical study

The estimation of the total percentage of every bacteria group over the 3-year period was possible, in spite of obtaining very low bacteria percentages for some of the groups, because of having a large sample of patients. Percentages of the conjunctival bacteria isolated month by month are represented in Figures 1–3, using Microsoft Excel 97, separated according to the typical site where they could come from.

The statistical significance of the differences between the conjunctival bacteria prevalence in different months was studied by means of the χ^2 test, using Microsoft Excel 97; the monthly differences of those bacteria groups having high percentages (Staphylococcus coagulase negative and *Corynebacterium* sp) were studied for the 11 months with 10 freedom degrees (fd). The monthly frequencies of the pathogen bacteria group (quite low) were considered to be different when they rose to a percentage much higher than the upper limit of the confidence interval (CI) of the total percentage of every bacteria group, and the frequencies of some months were grouped into two categories, following this criterion, to calculate the correspondent χ^2 test with one fd.

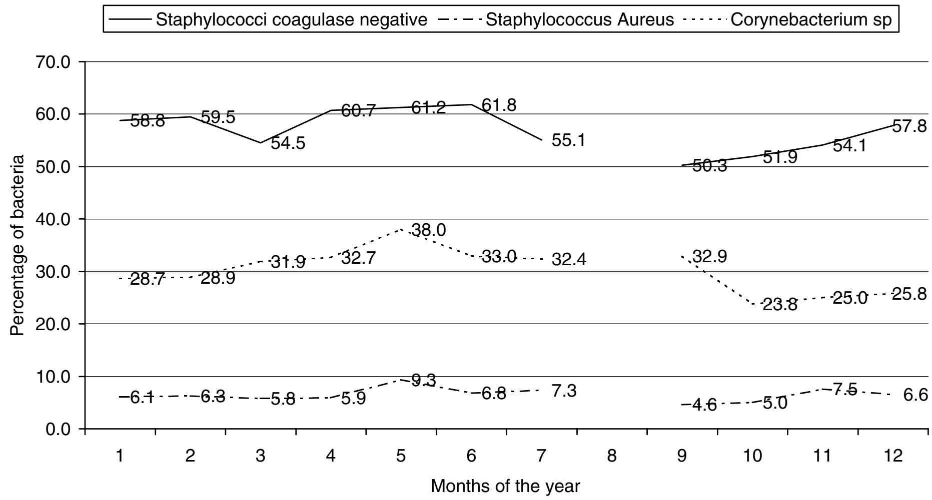

Figure 1 Monthly percentage of typical skin bacteria on the conjunctiva.

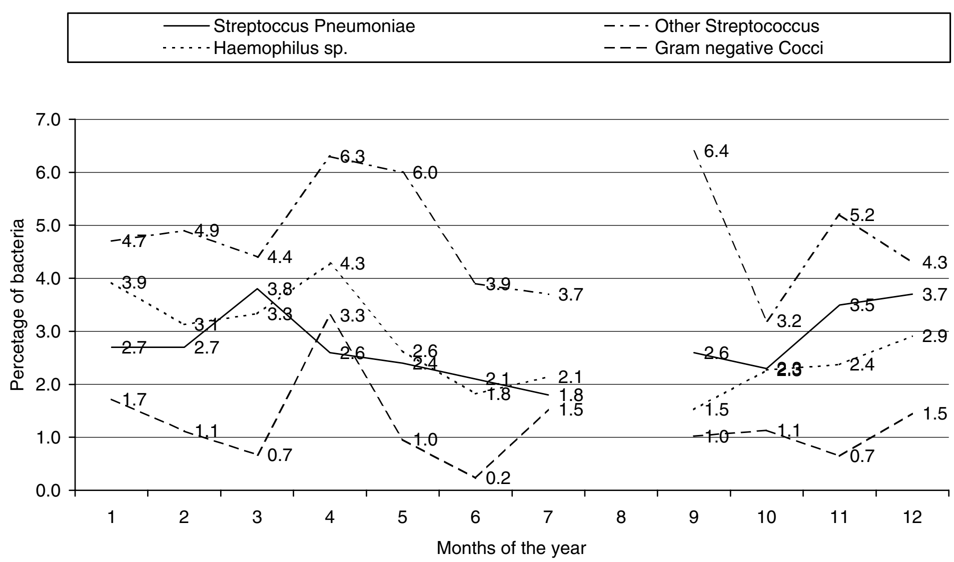

Figure 2 Monthly percentage of bacteria typical of the respiratory system on the conjunctiva.

Results

The number of analysed patients and the monthly frequency of every bacteria group are summarized in Table 1, except for the month of August, which has been removed from the study because the total number of cultures in the 3 years was less than a hundred and it was considered that those bacteria whose frequency was less than 1% could either be missed or overestimated.[23] More than one bacterium was isolated in some patients' conjunctiva, the total percentage of the isolated bacteria being higher than 100% in most of the months.

The percentage estimation of the conjunctival bacteria isolated in the 11 months considered is shown in Table 2. The whole bacteria percentage increases in April, May, and June quite much; over the total months[7] frequency (109.50%); the total percentage of pathogen bacteria increases over the upper CI limit of the total months' frequency (24, 20%) in April, May, November, and December (Table 1).

Among the monthly percentage of each of the nine bacteria groups represented in Figures 1–3, the increase of typical skin bacteria in May, and most bacteria typical of the respiratory system in April is very clear.

The statistical significance of the differences between the monthly frequency for every bacteria group is described in Table 3. The χ^2 tests for Staphylococcus coagulase negative and *Corynebacterium* sp groups turned

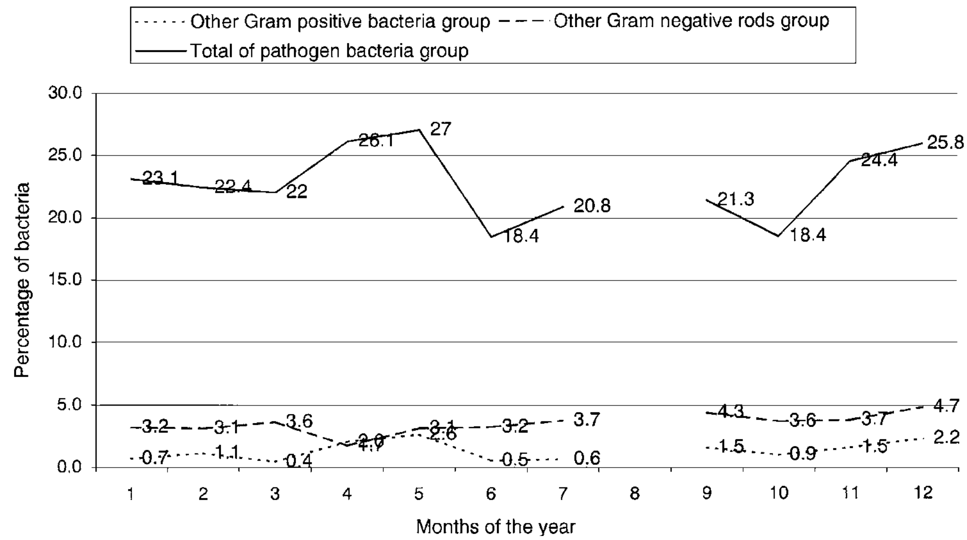

Figure 3 Monthly percentage of bacteria from other sources on the conjunctiva.

Table 1 Monthly frequency of grouped conjunctival bacteria in patients awaiting cataract surgery

Months	*January*	*February*	*March*	*April*	*May*	*June*	*July*	*September*	*October*	*November*	*December*	*Total*
Number of patients	408	447	451	303	418	440	327	392	441	464	275	4366
Staphylococci coagulase(−)	240	266	246	184	256	272	180	197	229	251	159	2480
Corynebacterium sp	117	129	144	99	159	145	106	129	105	116	71	1320
Staphylococcus Aureus	25	28	26	18	39	30	24	18	22	35	18	283
Streptococcus Pneumoniae	11	12	17	8	10	9	6	10	10	16	9	118
Other *Streptococcus* sp	19	22	20	19	25	17	12	25	14	24	13	210
Haemophilus sp	16	14	15	13	11	8	7	6	10	11	8	119
Gram-negative cocci	7	5	3	10	4	1	5	4	5	3	4	51
Other Gram-negative rods	13	14	16	5	13	14	12	17	16	17	13	150
Other bacteria	3	5	2	6	11	2	2	6	4	7	6	54
Total isolated	451	495	485	362	528	498	354	412	415	480	301	4781
% of total isolated	110.5	110.7	107.5	119.5	126.3	113.2	108.3	105.1	94.1	103.4	109.5	109.5
Total pathogen	94	100	99	79	113	81	68	86	81	113	71	985
% of total pathogens	23.0	22.4	22.0	26.1	27.0	18.4	20.8	21.3	18.4	24.4	25.8	22.6

Table 2 Statistical estimation of the percentages of preoperative conjunctival bacteria in 4366 patients awaiting cataract surgery in the eleven months considered

Bacteria group	N	*(%)*	*CI limits*[a]*(,)*
Staphylococcus coagulase (−)	2480	56.80	(54.85%, 58.75%)
Corynebacterium sp	1320	30.20	(28.39%, 32.01%)
Staphylococcus Aureus	283	6.40	(5.44%, 7.36%)
Streptococcus Pneumoniae	118	2.70	(2.06%, 3.34%)
Other *Streptococcus* sp	210	4.81	(3.97%, 5.65%)
Haemophilus sp	119	2.73	(2.09%, 3.37%)
Other Gram (−) rods	150	3.44	(2.72%, 4.16%)
Gram (−) Cocci	51	1.17	(0.75%, 1.59%)
Other Gram (+) bacteria	54	1.24	(0.80%, 1.68%)
Total pathogen bacteria	985	22.56	(20.09%, 24.20%)

Confidence interval limits, $P < 0.01$.

Table 3 Statistical significance of the monthly frequency differences in conjunctiva bacteria of 4366 patients awaiting cataract surgery over eleven months

Isolated bacteria	*Two Monthly frequency categories*	χ^2	*P-values*
Staphylococcus coagulase (−)	>60.0% and <60.0%	13.19	0.0003
Corynebacterium sp	>33.0% and <33.0%	13.35	0.0003
Staphylococcus Aureus	>8.0% and <8.0%	6.19	0.0129
Streptococcus Pneumoniae	>3.3% and <3.3%	4.25	0.0392
Other *Streptococcus* sp	>5.7% and <5.7%	6.30	0.0121
Haemophilus sp	>3.4% and <3.4%	4.79	0.0162
Other Gram-negative rods	>4.2% and <4.2%	1.89	0.1697
Gram-negative cocci	>3.0% and <3.0%	12.82	0.003
Other Gram-positive bacteria	>2.5% and <2.5%	7.36	0.0067
Total pathogen bacteria	>24.2% and <24.2%	7.86	0.0051

Table 4 Climatic data in the area where our patients live

	Monthly average humidity[a] (%)				*Monthly average temperature*[b] (°C)			
	1994	*1995*	*1996*	*1971–2000*[c]	*1994*	*1995*	*1996*	*1971–2000*[c]
January	70	72	81	71	6.1	6.8	7.9	6.1
February	70	72	64	65	7.1	8.9	6.4	7.9
March	57	52	61	54	13.9	11.5	10.2	10.7
April	54	48	56	55	12.1	14.5	14.0	12.3
May	61	48	61	54	16.8	18.9	15.8	16.1
June	45	47	45	46	22.7	22.0	22.8	21.0
July	41	39	41	39	27.8	26.4	25.0	24.8
August	48	44	46	41	24.6	25.1	23.6	24.4
September	59	53	56	50	18.6	18.3	18.3	20.5
October	72	61	65	64	15.4	17.5	15.0	14.6
November	78	78	70	70	11.3	11.7	10.2	9.7
December	79	86	83	74	7.2	8.3	7.4	7.0

[a]These data refer to the average Humidity during the whole 24 h a day.
[b]These data refer to the average Temperature during the whole 24 h a day.
[c]These data are the mean of the monthly average during these years.

out to be significant ($P<0.01$), May, June, and July being the months when frequencies increased. The results for other bacteria groups, studied for one fd, were as follows: the *Staphylococcus Aureus* frequency in May (>8%) was statistically different from that of the other months ($P=0.013$); the *Streptococcus Pneumoniae* frequency in March, November and December (>3.4%) was significantly higher than in the other months ($P=0.04$); the other *Streptococcus sp*. frequency increases significantly ($P=0.012$) in April, May, and September (>6%); *Haemophilus* sp increases significantly ($P=0.016$) in January and April (>3.4%); Gram-negative Cocci increase significantly ($P<0.001$) in April (>3%); and other Gram-positive bacteria increase significantly ($P=0.007$) in May (>2.5%).

In Table 4, the monthly average relative humidity (%) and temperature in degrees centigrade (°C) over the study period are given, as well as the mean of the monthly average of the same data for the period 1971–2000, in the area where our patients live. As the relative humidity in March, April, and May are quite similar, the increased conjunctival bacteria frequency over these months would more likely depend on temperature; for instance, we have found that all Gram-positive bacteria (except most *Streptococcus* sp) increased between 15 and 19°C in May; most bacteria typical of the respiratory system increased between 9 and 15°C in March, April, and November, except part of the *Haemophilus* sp which also increased under 9°C in January and February, and some *Streptococcus* sp (different from *Streptococcus Pneumoniae*), which also increased over 15°C in May and September.

Among the 4432 patients analysed in the 3-year study period, 851 were operated on during May and June. The operation took place more than a week after the preoperative culture. Therefore, the 851 patients operated on in May and June did not correspond exactly to the 858 preoperative conjunctival cultures processed in the same months. The incidence of rehospitalization for infectious PE of those patients operated on in May and June turned out to be 3.37 times higher than the incidence in the other 3581 patients operated on in other months.

Discussion

The influence of climatic factors on the monthly conjunctival bacteria prevalence of patients undergoing cataract surgery has been demonstrated in our area. In April, May, and June, the total frequency of conjunctival bacteria was surprisingly higher than in the other months (Tables 1 and 2); a large part of this increase was due to the normal flora that represent the most frequent ocular bacteria; however, the higher percentages of pathogen bacteria were found in April and May (Table 1), May being the month where most normal and pathogen bacteria were found on the conjunctiva. We did not find similar studies to compare our data with. Therefore, prospective studies involving more patients in every month would be useful to improve the statistical power.

To know if bacteria prevalence on the conjunctiva determines the prevalence of the infectious PE, it would be necessary to have operated on the patients on the same day such that their conjunctival content was cultured; this did not happen in our hospital, and therefore, it is impossible to demonstrate this association precisely. Moreover, among our infectious PE cases, in the study period, other coexisting risk factors such as patients suffering from diabetes, respiratory disease, pseudoexfoliation syndrome, and those having a secondary intraocular lens implant or other surgical complications, introduce a lot of statistical confusion, which cannot be clarified for some reasons. Firstly, we do not know the frequency of these coexisting risk factors in the whole sample of patients; secondly, even if we had had this information, the sample of infectious PE was too small to perform a statistical study with so many risk factors.

Nevertheless, we know that the incidence of rehospitalization for infectious PE after cataract extraction in May and June was 3.37 times higher than that observed in the other months of the year all together. These data agree with the increased infectious PE observed in Switzerland[1] and West Scotland[2] in the same months some years later. This agreement justifies the need for considering climatic factors as a predisposing condition to increase infectious PE incidence in a particular month, when future prospective studies are designed in order to determine the role of the different risk factors in the pathogenesis of this infection.

If we consider the spectrum of bacteria isolated in large series of infectious PE, Gram-positive bacteria were isolated in up to 80% of the cultures of PE samples after cataract extraction,[24,25] while about 10% of Gram-negative bacteria were identified; among Gram-positives, Staphylococci coagulase negative were the most frequently isolated, followed by *Staphylococcus Aureus*. Both kinds of bacteria present a similar proportion in preoperative conjunctival cultures;[23,26,27] both increase their prevalence in May and June in our area (Figure 1); and both are typical colonizers of the skin. When these bacteria are responsible for conjunctivitis, they are isolated in the same months at a high level too.[17]

In contrast, infectious PE due to bacteria typical of the respiratory system presents a more variable behaviour, and perhaps the presence of these bacteria on the conjunctiva is related to infections in respiratory diseases. For instance, in the mentioned study from West Scotland,[2] suffering from a respiratory disease turns out to be a risk factor for having PE after cataract surgery, but this was not described in other PE series studies. The prevalence of these bacteria over the year, in our patients (Figure 2), and the pattern of conjunctivitis in London,[18] which present an increase of the typical bacteria of the respiratory system in early spring and autumn, give the impression that respiratory bacteria appear and disappear on the conjunctiva in different months. This behaviour would explain why filtering blebs are associated with endophthalmitis due to *Streptococcus sp*. and *Haemophilus* sp and why this endophthalmitis occurs suddenly after there being no sign of infection for months since the last surgery.[28] For instance, in a series of late-onset endophthalmitis associated with filtering blebs, in the Bascom Palmer Eye Institute,[29] Streptococci were isolated in 57% of the cases and *Haemophilus influenzae* in 23%, and only two cases, from the 83% positive cultures, were due to Staphylococci.

No seasonal pattern was demonstrated for the group of Gram-negative rods (different from *Haemophilus* sp) in our sample (Figure 3), although they show a tendency to increase in the second part of the year; however, in a previous epidemiological study performed in our hospital, where preoperative conjunctival cultures were obtained in August, these Gram-negative rods increase statistically in the summer (panel communication to the Ophthalmology Spanish Society Congress in Sevilla, 1992). These Gram-negative rods, in spite of being responsible for only 6.5% of the intraocular specimens cultured in the largest case series of endophthalmitis presented 6 weeks after cataract extraction,[24] are those in which infection progresses quicker.[30]

Summarizing, all these data suggest that the monthly prevalence of the conjunctival bacteria in patients undergoing cataract extraction could predetermine the monthly incidence of infectious PE. In May and June, most conjunctival bacteria are Staphylococci, while bacteria typical of the respiratory system would be frequent in the early spring and autumn.

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