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IN VITRO ANTIBACTERIAL ACTIVITY OF SOME ANTIHISTAMINICS BELONGING TO DIFFERENT GROUPS AGAINST MULTI-DRUG RESISTANT CLINICAL ISOLATES

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ABSTRACT

Antihistaminics are widely used for various indications during microbial infection. Hence, this paper investigates the antimicrobial activities of 10 antihistaminics belonging to both old and new generations using multiresistant Gram-positive and Gram-negative clinical isolates. The bacteriostatic activity of antihistaminics was investigated by determining their MIC both by broth and agar dilution techniques against 29 bacterial strains. Azelastine, cyproheptadine, mequitazine and promethazine were the most active among the tested drugs. Diphenhydramine and cetirizine possessed weaker activity whereas doxylamine, fexofenadine and loratadine were inactive even at the highest tested concentration (1 mg/ml). The MIC of meclozine could not be determined as it precipitated with the used culture media. The MBC values of antihistaminics were almost identical to the corresponding MIC values. The bactericidal activity of antihistaminics was also studied by the viable count technique in sterile saline solution. Evident killing effects were exerted by mequitazine, meclozine, azelastine and cyproheptadine. Moreover, the dynamics of bactericidal activity of azelastine were studied by the viable count technique in nutrient broth. This activity was found to be concentration-dependant. This effect was reduced on increasing the inoculum size while it was increased on raising the pH. The post-antimicrobial effect of 100 µg/ml azelastine was also determined and reached up to 3.36 h.

Key words: Antihistaminics; bactericidal activity; bacteriostatic activity; Gram-negative isolates; Gram-positive isolates

INTRODUCTION

Antihistaminics are histamine H_1-antagonists -also known as H_1-receptor antagonists and H_1-antihistaminics (34). Chemically, they are classified into several classes including ethanolamines, ethylenediamines, piperazines, piperidines and phenothiazines where all the classes share a certain common structural feature (33). However, pharmacologically, they are classified into first-generation, whose members are sedating, and second-generation, whose members are relatively nonsedating and more selective; such classification is now more commonly used (32).

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Antihistaminics are available on the market in many pharmaceutical dosage forms for a variety of uses which mainly include the management of allergic conditions and the symptomatic treatment of cough and cold when used in compound preparations (34). Other uses of some antihistaminics include their use as antiemetic, anti-motion sickness, antiparkinsonism, sleep aids and appetizers (33, 34).

The use of antihistaminics in the drug regimen for patients who acquire microbial infection is inevitable and that gave rise to the need to assess the antimicrobial activity of antihistaminics. Few studies were previously carried out to demonstrate the antimicrobial activity of a number of antihistaminics which belonged mainly to the first generation especially the ethanolamine and phenothiazine antihistaminics; however, the published results are rather controversial.

Dastidar *et al.* (20) found that diphenhydramine and bromodiphenhydramine inhibited several Gram-positive and Gram-negative strains at concentrations ranging from 0.05 to 0.2 mg/ml. On the other hand, Semenitz (30) reported much higher MIC values for diphenhydramine that ranged from 1.8 to 15 mg/ml. However, certain members of phenothiazine antihistaminics were shown to have MIC that ranged mostly between 10 and 200 µg/ml against several Gram-positive and Gram-negative bacterial strains (16, 18, 21, 27, 29). Nonetheless, Shibl *et al.* (31) revealed MIC values as low as 1.6 µg/ml against a *S. aureus* strain. In addition to the varied MIC ranges, the spectrum of antibacterial activity was somehow variable in the previous studies where the tested phenothiazines were generally potent against the Gram-positive microorganisms; however their effect against the Gram-negative ones was either comparable to that against the Gram-positive ones or inferior to it. Moreover, some phenothiazine antihistaminics showed certain anti-tuberculosis activity (13, 17, 36).

As previous studies were almost restricted to some of the old members of antihistaminics while the new ones particularly those belonging to the second generation of antihistaminics almost received no attention from the microbiological point of view; for that reason, this paper deals with the microbiological testing of possible activities of 10 antihistaminics belonging to both old and new generations using antibiotic multiresistant clinical isolates.

MATERIALS AND METHODS

Microorganisms

A total of twenty five bacterial isolates was used in this study belonging to two Gram-positive and four Gram-negative genera. They were human isolates identified by classical microscopical and biochemical procedures (19, 23). In addition, the following standard strains were used: *Staphylococcus aureus* (ATCC 6538P), *Escherichia coli* (NCTC 10418), *Klebsiella pneumoniae* (ATCC 35657) and *Pseudomonas aeruginosa* (ATCC 9027). They were maintained at 4°C as slant cultures of sterile nutrient agar for a maximum of one month (35). Long term preservation was performed by freezing in 15% glycerol broth (26).

Antihistaminics

The antihistaminics used in this study were obtained as pure dry powders of pharmaceutical grade: Azelastine hydrochloride (Aze), Cetirizine dihydrochloride (Cet), Cyproheptadine hydrochloride (Cyp), Diphenhydramine hydrochloride (Dip), Doxylamine succinate (Dox), Fexofenadine hydrochloride (Fex), Loratadine (Lor), Meclozine hydrochloride (Mec), Mequitazine (Meq) and Promethazine (Pro). They were preserved at 4°C.

Preparation of antihistaminic stock solutions

Specified amounts of the tested antihistaminics were accurately weighed and transferred separately into suitable sterile volumetric flasks. Water soluble antihistaminic powders (azelastine, cetirizine, cyproheptadine, diphenhydramine, doxylamine, meclozine and promethazine) were dissolved in

sterile distilled water. Fexofenadine was dissolved in the minimal amount of methanol then diluted with sterile distilled water. Loratadine and mequitazine were dissolved in minimum amounts of 95% ethanol and dimethylsulphoxide (DMSO) respectively then diluted with sterile distilled water to form a colloidal dispersion.

Determination of minimum inhibitory concentration (MIC) of antihistaminics

The MIC of each antihistaminic against various strains employed in this study was determined by the broth macrodilution technique and the agar dilution technique as well (3).

Determination of minimum bactericidal concentration (MBC) of antihistaminics

The MBC of each antihistaminic against the tested strains was determined by the broth macrodilution technique (12) by subculturing 0.1 ml portions of each test tube showing no visible growth in the MIC experiment into test tubes containing 5 ml antihistaminic-free sterile nutrient broth (Oxoid).

Determination of the bactericidal activity of antihistaminics using the viable count technique

The bactericidal activity of antihistaminics in final concentrations ranging from 50 to 200 µg/ml was determined in sterile saline solution. Stock solutions of the antihistaminics at 10X the required concentrations were 10-fold diluted into the prepared bacterial suspensions and mixed at the zero time then incubated at 37°C for 24 hours. The final inoculum for each of the tested isolates was ~ 10^6 cells/ml in the sterile saline solution. Proper controls lacking the antihistaminics were included in each test.

Samples were aseptically withdrawn at 0, 6 and 24 h and 10-fold serially diluted with sterile saline solution. The number of survivors was determined by the surface viable count technique. The plates were incubated at 37°C for 24 h.

Determination of the dynamics of bactericidal activity of azelastine

Dynamics of bactericidal activity of 50 and 100 µg/ml azelastine were determined in nutrient broth. The inoculum size used was ~10^6 cells/ml. The systems were incubated in the shaking orbital incubator (A. Gallenkamp & Co. Ltd, United Kingdom) at 37°C and 35 strokes/min. Samples were aseptically withdrawn from each flask at 0, 3, 6 and 24 hours for the viable count determination.

Study of the effect of some factors on the bactericidal activity of azelastine

The effect of different factors on the bactericidal activity of azelastine was determined in nutrient broth by surface viable count technique. All systems were incubated in the shaking orbital incubator at 37°C and 35 strokes/min. The effect of azelastine concentrations ranging from 0 to 200 µg/ml was determined after withdrawing samples at 0 and 6 hours. The inoculum size used was ~ 10^6 cells/ml.

The effect of inoculum size was also studied; three inocula of about 10^3, 10^5 and 10^7 cells/ml were used. Similarly, the effect of 4 different pH values (5, 6, 7 and 8) was studied using the corresponding sterile phosphate buffers (14) at ~ 10^6 cells/ml inoculum size. The pH of each system was checked using pH meter (pH 211 Microprocessor pH meter, HANNA, Romania) after addition of azelastine and adjusted if necessary. Proper controls lacking azelastine were included for each inoculum size and pH. After incubation, samples were aseptically withdrawn at 0, 3, 6 and 24 hours for the previously described viable count technique.

Determination of the post-antimicrobial effect (PAE) of azelastine turbidimetrically (22)

An overnight broth culture of each of the selected isolates was 10^{-3} diluted in prewarmed sterile nutrient broth and incubated in a water-bath (GFL, Germany) at 37°C with agitation (50 rpm). The absorbance of the culture was monitored with a spectrophotometer using a wavelength of 600

nm, until an absorbance of ~0.25 was reached (equivalent to ~10^7 cells/ml). Treatment was carried out with 100 µg/ml azelastine. A control untreated flask was included in the experiment.

The bacteria–drug contact lasted 1 h, at the end of which drug activity was stopped by performing a 10^{-3} dilution to the cultures in drug-free prewarmed nutrient broth. The control culture was also subjected to the same dilution and growth turbidity was determined under identical conditions without antihistaminic exposure. All the cultures were further incubated at 37°C with agitation and the absorbance was measured hourly at 600 nm until > 0.1 O.D. was reached and the PAE was calculated as described by Dominguez *et al* (22).

RESULTS AND DISCUSSION

In the present work, a total of 29 bacterial strains and clinical isolates obtained from different sources were used. The identified clinical isolates showed multiresistance to different extents upon testing their susceptibility to 25 different antibiotics by the disc diffusion technique (4). Multiresistance was considered on the basis that the studied clinical isolates were resistant to antibiotics belonging to at least 3 classes and up to all tested antibiotics. Whereas the standard strains used were selected so that they were sensitive to the tested antibiotics.

The bacteriostatic activity of the antihistaminics under study was investigated through MIC determination against all the tested organisms both by broth and agar dilution techniques. Both methods yielded similar results shown in Table 1. Both the standard strains and the multiresistant clinical isolates showed similar responses to the action of the antihistaminics. The *Ps. aeruginosa* strains were insensitive to the tested antihistaminics at the studied concentration range except the phenothiazine ones, mequitazine and promethazine. The tested phenothiazines and cyproheptadine were the most effective among the studied antihistaminics and were active against both Gram-positive and Gram-negative bacteria. The obtained MIC range of promethazine was similar to the results obtained by Kristiansen and Moratensen (27), Chakrabarty *et al.* (16) as well as Molnar *et al.*(29) concerning the MIC of promethazine. However, Shibl *et al.* (31) determined the MIC of promethazine against only 1 strain (*S. aureus* NCTC 6571 standard strain) and found it to be 6.2 µg/ml, far lower than that obtained in the present work (Table 1). In that case, the authors only performed broth dilution technique using a different medium.

Azelastine, a new generation phthalazinone derivative, demonstrated significant bacteriostatic activity which was more pronounced against the tested Gram-positive organisms (Table 1), and hence it was used in further studies for reasons discussed later. It showed moderate activity against the tested *E. coli* and *Klebsiella* spp. strains.

Table 1. MIC ranges of antihistaminics

Organism (number of strains)	Meq	Pro	Cyp	Aze	Others[1]	Others[2]
	MIC, µg/ml					
S. aureus (5)	62.5-125	125-250	62.5-125	125-250	500-1000	>1000
S. epidermidis (2)	125	62.5	125	125	1000	>1000
E. faecium (2)	62.5	62.5-125	62.5	125	1000	>1000
E. coli (6)	125-250	250-500	125-250	1000	500- >1000	>1000
Klebsiella spp. (5)	62.5-125	125-250	62.5-250	125-1000	500- >1000	>1000
Pr. mirabilis (3)	250-1000	500-1000	250-1000	>1000	1000->1000	>1000
Ps. aeruginosa (6)	500	125-1000	>1000	>1000	1000->1000	>1000

Others[1]: Dip and Cet
Others[2]: Dox, Fex, Lor and Mec

Other antihistaminics shown also in Table 1 possessed a slight bacteriostatic activity, under the conditions of the test, against both tested Gram-positive and Gram-negative bacteria. These histamine antagonists were diphenhydramine and cetirizine, however, they lacked activity against the *Ps. aeruginosa* and *Pr. mirabilis* isolates in the tested concentration range. This agrees in part with the findings of Semenitz (30) and Dastidar *et al.* (20) regarding the activity of diphenhydramine. Moreover, Semenitz (30) reported 2 to 8 folds higher MIC values than those obtained in the present study (Table 1). On the contrary, Dastidar *et al.* (20) mentioned 200 µg/ml as MIC of diphenhydramine against several *S. aureus*, *E. coli*, *Kl. pneumoniae* and *Pr. mirabilis* isolates. This value is approximately half to quarter the level of MIC in Table 1. The other studied antihistaminics namely meclozine, loratadine, fexofenadine and doxylamine did not exhibit any bacteriostatic effects in the studied range of concentrations (Table 1). It is noteworthy to mention that the lack of activity of meclozine might be attributed to its precipitation with the phosphates and proteins upon the addition to either nutrient agar or nutrient broth.

The bactericidal activity of the antihistaminics under study was evaluated by the dilution methods (data not shown). The MBC values of the antihistaminics were mostly identical to their MIC values. The bactericidal activity of the tested antihistaminics was also investigated by the viable count technique against 4 Gram-positive and 4 Gram-negative clinical isolates exposed for 6 and 24 hr (Table 2). In this test, sterile saline solution which did not precipitate any of the tested antihistaminics was used. This system was also used to simulate some pharmaceutical dosage forms such as eye drops or nasal sprays or drops where the vehicle is the physiological isotonic solution. In case of azelastine, cyproheptadine and mequitazine the two concentrations used (50 and 100 µg/ml) were lower than those selected for the other antihistaminics (100 and 200 µg/ml) because of their relative high antibacterial activity. In general, increasing the concentration of the antihistaminics resulted in higher killing effects whenever an antihistaminic demonstrated antibacterial activity against a tested clinical isolate. However, Table 2 shows the results of the 100 µg/ml concentration of all tested antihistaminics to compare between their relative activities.

Table 2. Bactericidal effect of 100 µg/ml antihistaminics against selected isolates in 0.9% saline solution by viable count technique at 37°C.

Antihistaminic	Time, h	Organism*							
		Sa_{103}	Sa_{104}	Se_{101}	Ef_{101}	Ec_{103}	Ec_{105}	Kl_{102}	Ps_{102}
		Log Plating Efficiency							
Meq	6	-3.579	-3.146	-3.844	-4.145	-4.179	-1.948	-2.293	-3.672
	24	-2.838	-4.040	-3.777	-3.476	-3.426	-2.558	-3.845	-2.796
Cyp	6	-1.389	-1.032	-0.013	-1.192	-0.062	-0.320	0.029	-0.393
	24	-1.663	-2.087	-0.456	-2.176	0.068	-1.102	0.014	-0.199
Aze	6	-2.580	-1.690	-0.289	-3.146	-3.702	-0.550	-0.110	-0.371
	24	-2.838	-2.699	-1.875	-3.476	-5.264	-1.373	-0.474	-0.489
Mec	6	0.363	-1.243	-1.146	-1.192	-0.599	-1.333	-0.069	-1.092
	24	-2.838	-4.040	-2.477	-2.000	0.078	-2.868	-0.469	-0.799
Dip	6	-0.103	-0.544	0.196	-0.146	-0.096	-0.032	0.083	-0.009
	24	-1.839	-0.087	-0.234	-1.097	0.014	-1.248	-0.026	-0.246
Cet	6	-0.349	-0.669	-0.088	-0.867	-0.660	-0.897	-0.008	-0.029
	24	-1.838	-3.040	-0.499	-1.097	-1.094	-1.558	-0.117	-0.938
Dox	6	0.101	0.385	-0.414	0.000	0.131	0.249	0.071	-0.417
	24	0.349	0.357	-1.632	-0.310	0.043	-0.409	0.012	-0.074
Fex	6	0.312	0.535	0.234	-0.105	0.062	0.103	-0.026	-0.827
	24	0.426	-0.219	-0.135	-0.316	0.057	-1.134	0.024	-1.090
Lor	6	-0.376	-0.209	0.058	-0.327	0.165	0.282	-0.008	-0.330
	24	-0.392	-1.082	-0.444	-0.394	-0.032	-0.524	-0.017	-0.881

*Organisms. Sa_{103} and Sa_{104}: *S. aureus* isolates, Se_{101}: *S. epidermidis*, Ef_{101}: *E. faecium* isolate, Ec_{103} and Ec_{105}: *E. coli* isolates, Kl_{102}: *Kl. Pneumonia* isolate, Ps_{102}: *Ps. aeruginosa* isolate

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