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Original Article

Effects of levofloxacin combined with dexamethasone ear drops on suppurative otitis media and analysis of influencing factors

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Abstract: Objective: To analyze the effects of levofloxacin combined with dexamethasone ear drops on suppurative otitis media (SOM) and factors influencing the effects. Methods: A total of 149 patients with SOM admitted to Liangxiang Hospital, Fangshan District were selected and allocated to the control group (n = 70, treated with levofloxacin) or the research group (n = 79, treated with levofloxacin combined with dexamethasone ear drops) in this retrospective study. The following parameters were collected from both groups: treatment efficacy, pathogen clearance rate, adverse reactions, hearing metrics, time to symptom resolution, and serum biochemical parameters. Subsequently, univariate and multivariate analyses were performed to assess factors influencing treatment efficacy. Results: The total effective rate (P = 0.001) and pathogen clearance rate (P = 0.012) in the research group were notably higher than those in the control group, while the overall incidence of adverse reactions (P = 0.005), post-treatment hearing metrics (P < 0.05), time to symptom resolution (P < 0.01), and serum biochemical parameters (P < 0.05) were notably lower than those in the control group. Univariate and multivariate analyses identified tympanic membrane perforation size (P = 0.003), disease activity (P = 0.040), and treatment method (P = 0.004) as independent factors influencing treatment efficacy in SOM patients. Conclusion: Levofloxacin combined with dexamethasone ear drops has a significant effect on SOM. For patients with active purulent ear discharge, and large tympanic membrane perforation, levofloxacin combined with dexamethasone has a lower risk of treatment failure.

Keywords: Levofloxacin, dexamethasone, suppurative otitis media, efficacy, analysis of influence factors

Introduction

Otitis media is an inflammation of the middle ear mucosa. Its related complications and sequelae may lead to hearing loss and even deafness, placing a heavy burden on patients' families and the healthcare system [1, 2]. Suppurative otitis media (SOM) is defined as purulent inflammation of the middle ear mucosa, categorized into acute and chronic forms [3]. Acute SOM develops rapidly. If left untreated for an extended period, it may progress to chronic SOM (CSOM), increasing treatment difficulty [4]. Both acute and chronic conditions have a negative impact on hearing, and in severe cases, they may lead to permanent sensorineural hearing loss [5]. Patients with SOM typically present with clinical symptoms such as ear pain, tympanic membrane hyperemia, and fever. In addition to hearing impairment, the condition may trigger complications such as throbbing headache and meningitis, posing a threat to patients' health and life [6]. The etiology of this disease is closely related to bacterial infections. Current treatment for SOM patients focuses mainly on pus drainage and infection control, but no effective cure exists [7, 8].

Levofloxacin, as a representative drug of the third-generation quinolone antibiotics, has an effective inhibitory effect on various bacteria including staphylococci and Streptococcus pyogenes [9]. The antibacterial mechanism is related to its inhibitory effect on bacterial DNA gyrase [10]. Levofloxacin intervention effectively inhibits external auditory canal inflammation and improves bacterial clearance in CSOM and acute otitis media patients [11]. Dexamethasone, as a steroid by nature, exerts anti-oti-

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tis therapeutic effects by suppressing immune system responses, reducing inflammation, relieving ear symptoms, and promoting wound healing; besides, dexamethasone-based combination therapy further relieves symptoms and prevents adverse reactions [12]. Levofloxacin combined with dexamethasone effectively prevents infection and controls inflammation in patients undergoing cataract surgery, and is well tolerated; however, reports on this therapy for SOM remain limited [13]. Currently, there is limited research on the treatment of SOM with levofloxacin combined with dexamethasone ear drops. Most studies have primarily focused on monotherapy with either levofloxacin or dexamethasone, or the combination of ofloxacin and dexamethasone for managing SOM [12, 14, 15]. The efficacy of levofloxacin combined with dexamethasone ear drops for the treatment of SOM remains unclear.

This study evaluated the effects of levofloxacin combined with dexamethasone ear drops in the treatment of SOM and investigated the factors influencing treatment efficacy, aiming to identify an effective cure for this patient population, which represents the innovation of this study.

Materials and methods

Patient information

Inclusion criteria: Diagnosis of SOM confirmed by ear and hearing examination [16]; aged 30-70 years; unilateral ear infection; no antibiotic or symptomatic supportive treatment within the past 3 days; complete clinical data.

Exclusion criteria: History of otorhinolaryngology surgery; presence of other ear diseases; allergy to the study drug; positive X-ray examination of the mastoid process; immune system or blood system diseases; severe heart, lung, kidney, or endocrine system diseases; mental disorders or speech/hearing disorders; pregnancy or lactation.

This retrospective study has obtained approval from the Ethics Committee of the Liangxiang Hospital, Fangshan District. In this study, 109 patients with SOM admitted to Liangxiang Hospital from September 2022 to September 2025 were strictly screened against the above inclusion and exclusion criteria as the study subjects. Among them, 70 cases in the control group were treated with levofloxacin, and 79 cases in the research group were treated with levofloxacin combined with dexamethasone ear drops.

Methods

All patients underwent examinations for hearing impairment and infection after admission. Subsequently, the affected external auditory canal and middle ear cavity were irrigated with 3% hydrogen peroxide solution, and pus was aspirated using a purulent discharge collector until no pus was visible, followed by a second irrigation.

The control group was treated with levofloxacin. The specific procedures were as follows: The patient lay on their side with the affected ear facing upward. Using a sterile cotton swab, 1% bupivacaine hydrochloride injection was applied to the surface of the tympanic membrane for topical anesthesia. Under otoscopic guidance, the ear cavity was flushed with levofloxacin hydrochloride ear drops, followed by negative pressure suction. Subsequently, 1-3 drops of levofloxacin ear drops were administered according to the patient's symptoms. The physician could adjust the dose based on disease severity. The standard regimen was 1 drop per application, once daily.

Patients in the research group received dexamethasone in combination with the regimen of the control group. During levofloxacin ear irrigation, dexamethasone sodium phosphate injection was supplemented at a concentration of 20 mg per 100 mL levofloxacin ear drops. The same ratio was applied during the ear dripping process. All other procedures were the same as those in the control group. All patients were treated for 12 consecutive days.

Outcome measures

Baseline data. Baseline data were collected and compared between groups, including gender, age, disease duration, affected ear, tympanic membrane perforation size, and disease activity. Tympanic membrane perforation size was assessed based on the ratio of perforated to intact membrane area, categorized as small

(0-25%), medium (25-75%), or large (75-100%). Disease activity was categorized as active suppurative otitis ear (defined by the presence of purulent discharge) or active mucoid otitis ear (defined by the presence of mucoid discharge (intermediate between pus and mucus)) [17].

Efficacy. Efficacy evaluation criteria: Cured: resolution of all clinical symptoms (ear pain, tympanic membrane hyperemia, fever, etc.), dryness in the ear canal without secretions, and full restoration of hearing. Markedly effective: marked alleviation of clinical symptoms compared to pre-treatment, reduced ear canal secretions, tympanic membrane hyperemia, and near-complete restoration of hearing. Effective: improvement in clinical symptoms compared to pre-treatment, some reduction in ear canal secretions, and lessened tympanic membrane hyperemia. Ineffective: failure to meet any of the above criteria. The total effective rate is the sum of the cure rate, the markedly effective rate, and the effective rate.

Pathogen clearance rate. Criteria for pathogen clearance: Complete clearance: no pathogen detected in ear canal secretions. Presumed clearance: symptoms improved, but ear canal secretions not tested due to unforeseen factors. No clearance: pathogen detected in ear canal secretions. Total clearance rate = complete clearance + presumed clearance.

Adverse reactions. The number of cases of adverse events such as nausea, dizziness, inner ear fullness, and inner ear burning sensation were monitored and recorded after treatment, and the corresponding percentages were calculated.

Hearing metrics. Pure-tone audiometry was used to assess patients' hearing function before and after treatment, evaluating the average hearing thresholds at 500 Hz, 1,000 Hz, and 2,000 Hz.

Time to symptom resolution. After treatment, the time to resolution of symptoms such as ear pain, tympanic membrane hyperemia, and fever was compared between the two groups.

Serum biochemical parameters. Fasting venous blood (3 mL) was drawn before and after treatment. Serum levels of procalcitonin (PCT), interleukin-8 (IL-8), and transforming growth factor (TGF)-β were determined using enzyme-linked immunosorbent assay (ELISA).

Statistical analysis

The Shapiro-Wilk test was used to evaluate whether the measurement data conformed to a normal distribution. Normally distributed data were expressed as mean ± standard deviation (SD), with the t-test used for intergroup comparisons and the paired t-test for pre- and post-treatment comparisons. Non-normally distributed data were expressed as median (interquartile range) [M (Q1, Q3)], with the Mann-Whitney U test used to evaluate differences between groups. Categorical data were presented as number/percentage (n/%), and intergroup comparisons were conducted using the chi-square (χ^2) test. Factors influencing efficacy were analyzed using univariate and multivariate analyses. SPSS 24.0 statistical software was used for data analysis. A *P*-value < 0.05 was considered statistically significant.

Results

Comparison of general data

Baseline data, including gender, age, disease duration, affected ear, tympanic membrane perforation size, and disease activity, showed no statistically significant differences between the control and the research groups (all P > 0.05) (**Table 1**).

Comparison of treatment efficacy

The total number of effective cases was 52 in the control group and 74 in the research group, which was significantly higher in the latter (P = 0.001) (**Table 2**).

Comparison of pathogen clearance rate

The total number of cases with pathogen clearance was 52 in the control group and 71 in the research group, which was significantly higher in the latter (P = 0.012) (**Table 3**).

Comparison of adverse reactions

Adverse reactions (nausea, dizziness, inner ear fullness, and inner ear burning sensation) were evaluated and compared between the two

Table 1. General data in the two groups

Item	Control group (n = 70)	Research group (n = 79)	χ^2/t	P
Gender			0.724	0.395
Male	35 (50.00)	45 (56.96)		
Female	35 (50.00)	34 (43.04)		
Age (years)	44.31 ± 8.02	44.91 ± 8.20	0.450	0.653
Disease duration (d)	9.99 ± 3.32	9.71 ± 3.31	0.515	0.608
Affected ear			0.074	0.786
Left	33 (47.14)	39 (49.37)		
Right	37 (52.86)	40 (50.63)		
Clinical stage			0.361	0.548
Acute	45 (64.29)	47 (59.49)		
Chronic	25 (35.71)	32 (40.51)		
Tympanic membrane perforation size			1.639	0.441
Small	6 (8.57)	12 (15.19)		
Medium	40 (57.14)	40 (50.63)		
Larger	24 (34.29)	27 (34.18)		
Disease activity			3.018	0.082
Active suppurative otitis ear	44 (62.86)	60 (75.95)		
Active mucoid otitis ear	26 (37.14)	19 (24.05)		

Table 2. Efficacy

Indicator	Control group (n = 70)	Research group (n = 79)	χ^2	P
Cured	19 (27.14)	28 (35.44)		
Markedly effective	22 (31.43)	30 (37.97)		
Effective	11 (15.71)	16 (20.25)		
Ineffective	18 (25.71)	5 (6.33)		
Total effective rate	52 (74.29)	74 (93.67)	10.685	0.001

Table 3. Pathogen clearance rate

Item	Control group (n = 70)	Research group (n = 79)	χ^2	P
Complete clearance	45 (64.29)	65 (82.28)		
Assumed clearance	7 (10.00)	6 (7.59)		
No clearance	18 (25.71)	8 (10.13)		
Total clearance	52 (74.29)	71 (89.87)	6.260	0.012

Table 4. Adverse reactions

Item	Control group (n = 70)	Research group (n = 79)	χ^2	P
Nausea	2 (2.86)	0 (0.00)		
Dizziness	4 (5.71)	1 (1.27)		
Inner ear fullness	5 (7.14)	2 (2.53)		
Inner ear burning sensation	6 (8.57)	3 (3.80)		
Total	17 (24.29)	6 (7.59)	7.921	0.005

groups. The research group exhibited a notably lower overall incidence of adverse reactions (P = 0.005) (**Table 4**).

Comparison of hearing metrics

The 500 Hz, 1,000 Hz, and 2,000 Hz hearing thresholds showed no statistically significant differences between the two groups at baseline (P > 0.05). After treatment, all hearing thresholds decreased to varying degrees (all P < 0.01), with the research group exhibiting significantly lower values (all P < 0.05) (**Figure 1**).

Comparison of time to symptom resolution

Comparison of time to resolution of symptoms such as ear pain, tympanic membrane hyperemia and fever revealed shorter resolution

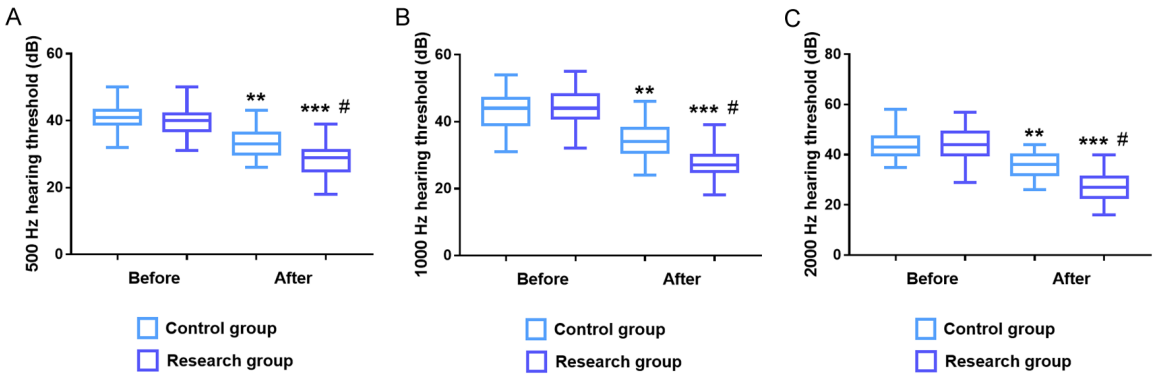

Figure 1. Hearing metrics. A. 500 Hz hearing threshold before and after treatment. B. 1,000 Hz hearing threshold before and after treatment. C. 2,000 Hz hearing threshold before and after treatment. Note: **P < 0.01, ***P < 0.001, compared with before treatment; #P < 0.05, compared with the control group.

Table 5. Time to symptom resolution

Item	Control group (n = 70)	Research group (n = 79)	Z	P
Ear pain (d)	4.50 (3.75, 6.00)	3.00 (2.00, 4.00)	-5.289	< 0.001
Tympanic membrane hyperemia (d)	5.00 (3.75, 6.00)	4.00 (3.00, 5.00)	-2.672	0.008
Fever (d)	3.00 (3.00, 4.00)	3.00 (2.00, 3.00)	-3.881	< 0.001

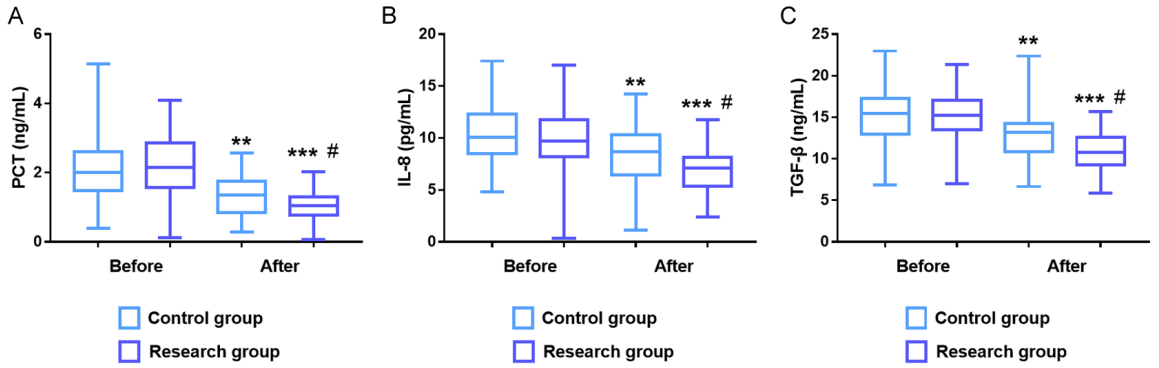

Figure 2. Serum biochemical parameters. A. PCT before and after treatment. B. IL-8 before and after treatment. C. TGF-β before and after treatment. Note: **P < 0.01, ***P < 0.001, compared with before treatment; #P < 0.05, compared with the control group. PCT, procalcitonin; IL-8, interleukin-8; TGF-β, transforming growth factor-β.

times for all symptoms in the research group (all P < 0.05) (**Table 5**).

Comparison of serum biochemical parameters

No considerable intergroup differences were observed in serum biochemical parameters, including PCT, IL-8, and TGF-β, at baseline (all P > 0.05). After treatment, all these parameters showed notable reductions (all P < 0.01), with lower values in the research group (all P < 0.05) (**Figure 2**).

Factors influencing efficacy in patients with SOM

Univariate analysis revealed that efficacy was not significantly associated with gender, age, affected ear, baseline 500 Hz hearing threshold, baseline 1,000 Hz hearing threshold, baseline 2,000 Hz hearing threshold, baseline PCT, baseline IL-8, or baseline TGF-β (all P > 0.05), but was closely related to disease duration, clinical stage, tympanic membrane perforation size, disease activity, and treatment method (all P < 0.05) (**Table 6**).

Table 6. Univariate analysis

Item	Ineffective group (n = 23)	Effective group (n = 126)	χ^2	P
Gender			0.025	0.874
Male (n = 80)	12 (52.17)	68 (53.97)		
Female (n = 69)	11 (47.83)	58 (46.03)		
Age (years)			0.331	0.565
< 44 (n = 73)	10 (43.48)	63 (50.00)		
≥ 44 (n = 76)	13 (56.52)	63 (50.00)		
Disease duration (d)			6.603	0.010
< 10 (n = 69)	5 (21.74)	64 (50.79)		
≥ 10 (n = 80)	18 (78.26)	62 (49.21)		
Affected ear			0.003	0.958
Left ear (n = 72)	11 (47.83)	61 (48.41)		
Right ear (n = 77)	12 (52.17)	65 (51.59)		
Clinical stage			5.889	0.015
Acute (n = 92	9 (39.13)	83 (65.87)		
Chronic (n = 57)	14 (60.87)	43 (34.13)		
Tympanic membrane perforation size				0.030
Small/medium (n = 98)	20 (86.96)	78 (61.90)		
Large (n = 51)	3 (13.04)	48 (38.10)		
Disease activity			12.135	< 0.001
Active suppurative otitis ear (n = 104)	9 (39.13)	95 (75.40)		
Active mucoid otitis ear (n = 45)	14 (60.87)	31 (24.60)		
Baseline 500 Hz hearing threshold (dB)			0.190	0.663
< 41 (n = 71)	10 (43.48)	61 (48.41)		
≥ 41 (n = 78)	13 (56.52)	65 (51.59)		
Baseline 1000 Hz hearing threshold (dB)			0.792	0.374
< 44 (n = 71)	9 (39.13)	62 (49.21)		
≥ 44 (n = 78)	14 (60.87)	64 (50.79)		
Baseline 2000 Hz hearing threshold (dB)			0.264	0.608
< 43 (n = 64)	11 (47.83)	53 (42.06)		
≥ 43 (n = 85)	12 (52.17)	73 (57.94)		
Baseline PCT (ng/mL)			1.059	0.304
< 2.08 (n = 73)	9 (39.13)	64 (50.79)		
≥ 2.08 (n = 76)	14 (60.87)	62 (49.21)		
Baseline IL-8 (pg/mL)			0.416	0.519
< 9.92 (n = 74)	10 (43.48)	64 (50.79)		
≥ 9.92 (n = 75)	13 (56.52)	62 (49.21)		
Baseline TGF-β (ng/mL)			0.069	0.794
< 15.43 (n = 74)	12 (52.17)	62 (49.21)		
≥ 15.43 (n = 75)	11 (47.83)	64 (50.79)		
Treatment method			10.685	0.001
Levofloxacin (n = 70)	18 (78.26)	52 (41.27)		
Levofloxacin plus dexamethasone (n = 79)	5 (21.74)	74 (58.73)		

Note: PCT, procalcitonin; IL-8, interleukin-8; TGF-β, transforming growth factor-β.

In further multivariate analysis, disease duration and clinical stage showed no statistical significance (all P>0.05), whereas tympanic membrane perforation size, disease activity,

Table 7. Multivariate analysis

Item	B	SE	WALD	P	OR	95% CI
Disease duration (d)	1.136	0.626	3.297	0.069	3.116	0.914-10.625
< 10 = 0						
10 = 1						
Clinical stage	0.834	0.548	2.316	0.128	2.303	0.786-6.743
Acute = 0						
Chronic = 1						
Tympanic membrane perforation size	-2.163	0.734	8.692	0.003	0.115	0.027-0.484
Small/medium = 0						
Large = 1						
Disease activity	1.142	0.555	4.233	0.040	3.132	1.056-9.291
Active suppurative otitis ear = 0						
Active mucoid otitis ear = 1						
Treatment method	-1.762	0.605	8.490	0.004	0.172	0.052-0.562
Levofloxacin = 0						
Levofloxacin plus dexamethasone = 1						

Note: SE, Standard Error; OR, Odds Ratio; 95% CI, 95% Confidence Interval.

and treatment method were identified as independent factors influencing treatment efficacy in SOM patients (all $P < 0.05$). Specifically, patients with large perforations had an 88.5% lower risk of treatment failure compared to those with small/medium perforations (OR = 0.115, P = 0.003); patients with active mucoid otitis ear had a 3.13-fold higher risk of treatment failure than those with active suppurative otitis ear (OR = 3.132, P = 0.040); levofloxacin combined with dexamethasone reduced the risk of treatment failure by 82.8% (OR = 0.172, P = 0.004) (**Table 7**).

Discussion

In this study, the combination of levofloxacin and dexamethasone ear drops further enhanced treatment efficacy and improved pathogen clearance rates in SOM patients. The superior efficacy of this combination may stem from their distinct mechanisms of action. Levofloxacin primarily inhibits bacterial DNA replication and transcription by suppressing DNA gyrase activity, thereby achieving antibacterial effects [18]; whereas dexamethasone alleviates SOM by enhancing vascular permeability, inhibiting inflammatory cell aggregation, and maintaining balance in the inflammatory microenvironment [19]. Regarding safety, the combined regimen further reduced the overall risk of adverse reactions (including nausea, dizziness, inner ear fullness, and inner ear burning sensation) in SOM patients. One study reported no interactions when levofloxacin combined with dexamethasone was administered as eye drops to patients receiving cataract surgery, suggesting the potential clinical safety of this combination [20]. In a study from Takahashi et al. [15], levofloxacin intervention facilitated the resolution of middle ear and tympanic membrane inflammation in otitis media patients without causing death or serious treatment-related adverse events, suggesting the clinical efficacy and safety of this therapy. According to Mârţu et al. [21], intra-tympanic injection of dexamethasone as a local corticosteroid delivery therapy in SOM with serous otitis media is effective and safe.

In terms of auditory function, the combined intervention notably reduced hearing thresholds at 500 Hz, 1,000 Hz, and 2,000 Hz in SOM patients, thereby more effectively restoring patients' hearing capabilities. This may be attributed to the superior efficacy of the combined therapy in suppressing inflammation, which enhances local circulation, promotes metabolic normalization, and repairs the periosteum and other ear tissues. A mouse study indicated that dexamethasone protects against sensory epithelial damage in a genetic deafness model, partially restoring hearing loss; the mechanism may relate to the regulation of inner ear immune response by dexamethasone [22]. Regarding symptom resolution, the com-

bined regimen demonstrated a greater clinical advantage, as evidenced by notably shorter symptom resolution times for ear pain, tympanic membrane hyperemia, and fever. Dexamethasone in the combined regimen enhances vascular permeability, facilitating more efficient transport of nutrients and other substances required for ear canal self-repair, which promotes symptom resolution and improves therapeutic efficacy [23, 24]. Furthermore, we found that the combination of levofloxacin and dexamethasone ear drops remarkably reduced serum biochemical indicators such as PCT, IL-8, and TGF-β in SOM patients. These three indicators reflect the inflammatory response in SOM patients. Elevated PCT levels correlate closely with severe bacterial or fungal infections; high IL-8 suggests intensified local inflammatory reactions; and increased TGF-β reflects the tissue repair process associated with inflammation [25-27]. These findings suggest that the combination of levofloxacin and dexamethasone ear drops provides more effective suppression of inflammatory responses in patients with SOM. Dexamethasone may exert its anti-inflammatory effects by inhibiting the Toll-like receptor 4/nuclear factor kappa B pathway in macrophages through the glucocorticoid receptor -serum/glucocorticoid-regulated kinase 1 -store-operated calcium entry -Piezo-type mechanosensitive ion channel component 1 signaling axis, thereby downregulating serum levels of PCT, IL-8, and TGF-β [28].

Multivariate analysis identified tympanic membrane perforation size and treatment method as independent protective factors for treatment efficacy in SOM patients, while disease activity was an independent risk factor. This indicates that larger tympanic membrane perforations, lower disease activity (active suppurative otitis ear), and combined therapy (levofloxacin combined with dexamethasone ear drops) help reduce the risk of treatment failure. A large tympanic membrane perforation may serve as a protective factor by enhancing drug permeability, allowing medications to reach the infection site more effectively and thereby increasing efficacy. In contrast, suppurative otitis may be more difficult to cure, which could be related to the formation of biofilms or a more complex pathogen profile, consequently increasing the difficulty of treatment.

This study has several limitations: First, all the samples were from a single center, which may lead to insufficient sample representativeness. In the future, samples from multiple centers should be adopted to enhance the representativeness of the sample size as much as possible. Second, no analysis was conducted on indicators such as sleep quality and quality of life. Supplementing these data would help further determine the potential clinical advantages of the combined treatment regimen. Third, long-term prognosis assessment was not carried out. A follow-up period longer than 3 years is beneficial for exploring the prognostic impact of the combined treatment regimen. Future analyses will be gradually refined in light of these considerations.

In summary, levofloxacin combined with dexamethasone ear drops demonstrates a definite therapeutic effect in patients with SOM. This regimen effectively eradicates bacteria, reduces the overall risk of adverse reactions, improves hearing function, promotes rapid symptom resolution, and lowers abnormally elevated levels of PCT, IL-8, and TGF-β. Patients with large tympanic membrane perforations and low disease activity (Active suppurative otitis media), may achieve greater clinical benefits from combined treatment with levofloxacin and dexamethasone ear drops.

Disclosure of conflict of interest

None.

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