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Original Article

Impact of Sulphurous Water Politzer Inhalation on Audiometric Parameters in Children with Otitis Media with Effusion

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Objectives. The positive effects of spa therapy on ear, nose, and throat pathology are known but robust literature in this field, is still lacking. The aim of this study was to assess through a retrospective analysis, the effects on otitis media with effusion of Politzer endotympanic inhalation of sulphurous waters in children aged 5-9 years.

Methods. A cohort of 95 patients was treated with Politzer insufflations of sulphurous water: 58 patients did a cycle consisting of a treatment of 12 days per year for three consecutive years; 37 patients followed the same procedure for 5 years consecutively. The control population was represented by untreated, age-matched children. A standard audiometric test was used before and after each cycle of treatment.

Results. One cycle of Politzer inhalation of sulphur-rich water improved the symptoms. Three cycles definitively stabilized the improvement of hearing function.

Conclusion. Our results show that otitis media with effusion in children can be resolved by an appropriate non-pharmacological treatment of middle ear with sulphur-rich water.

Keywords. *Otitis media, Pediatric audiology, Sulphur hydrogen, Spa therapy*

INTRODUCTION

Recent evidence suggests that the use of mineral waters for therapeutic purposes in human diseases relies on precise molecular mechanisms [1-4]. Indeed, paramount scientific literature reports the clinical evidence of a therapeutic benefit of the use of mineral water in several pathologies [5,6]. In particular, spa therapy of the upper respiratory airways and ears is a classical longstanding methodology to improve the status of the head and neck mucosa [7,8]. The type of water used in these therapies is more often rich in sulphur ions [7,9] and it has been demonstrated that its positive effects can be essentially ascribed to a lubricant action on the mucus, a normalizing action on the mucociliary clearance and bactericidal properties [7,9,10].

Hydrogen sulphide (H_2S)—known for decades as a toxic gas—is endogenously generated from cysteine, in reactions catalyzed by cystathionine γ-synthase (CBS) and cystathionine γ-lyase (CSE) [11,12]. New data on endogenously generated H_2S has now included this gas in the family of gasotransmitters, together with nitric oxide (NO) and carbon monoxide (CO), and the variety of its effects is now understood at the cellular and molecular levels [11-13]. Perhaps the best characterized physiological effect of H_2S to date, is the relaxation of vascular smooth muscle cells, generated by H_2S-mediated K_{ATP} channel opening [11-13]. H_2S can induce an upregulation of anti-inflammatory and cytoprotective genes including heme-oxygenase-1 (HMOX1) [1,11,13], cytochrome c oxidase subunit ν, vascular endothelial growth

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factor (VEGF), insulin-like growth factor (IGF) receptor and several genes associated with the transforming growth factor-β (TGF-β) receptor pathway [1,2,11,13].

Despite the availability of this basic scientific information, the evidence of clinical efficacy of exogenously administered H_2S is still quite weak, hampered by the lack of robust scientific literature; furthermore data is lacking with regards to children, which is undoubtedly the most relevant group of subjects affected by inflammatory ENT pathology [14].

Therefore, at the ENT centre of a well known Italian medical spa, we monitored a cohort of children diagnosed with chronic inflammation of the upper airways resulting in rhinogenic deafness. This common pathology is usually seen in children under 8-10 years of age and is bilateral in 80% of the cases [14,15]. It usually starts as a simple episode of classic middle ear infection but it tends to be recurrent and self-maintaining, thus exacerbating the local chronic inflammation that produces endotympanic effusion. A conductive hearing loss of various degrees is always present and parents' attention is pivotal for early diagnosis. Treatment is aimed to restore ventilation in the middle ear, to resolve the chronic inflammatory state and to recover the hearing function [14,15]. Despite existing doubts in approaching this pathology (use of antibiotics and steroids), first-choice treatments are aerosol therapy with topical corticosteroids and mucolytics, and nasal decongestants [14,15]. As a first-choice treatment, spa therapy can be also considered; it should be preferred because it is almost void of side effects and usually cost-effective. The standard treatment for the young patient is a Politzer endotympanic inhalation [7,14] using sulphurous waters.

Our purpose here was therefore to test the efficacy of spa therapy approach alone in the restoration of hearing function in young children, also in the view of the important effects on speech learning and school performance of this particular middle ear pathology.

MATERIALS AND METHODS

This retrospective observational study analyzed registered audiometric data obtained in a cohort of children aged 5 to 9 affected by a hearing impairment due to chronic upper airway inflammatory status.

Diagnosis was made on the basis of a visual inspection by an otoscope after careful examination of the clinical history of the patients with the help of their parents: in particular every case of unresolved middle ear infection was considered. Exclusion criteria was: 1) pharmacologic treatment in the previous three months; 2) hearing impairment at birth; 3) bacterial otitis media; 4) any cause of bone conduction-caused hearing alterations. Inclusion criteria was: 1) pharyngeal tonsil hypertrophy associated with rhinitis and otitis media; 2) chronically recurrent otitis; 3) catarrhal otitis media.

Written informed consent was obtained by the patients' parents or guardians at the time of enrolment. Clinical data was retrieved from a total of 95 subjects. Fifty-eight were treated by one cycle of therapy per year for a total of three consecutive years (patients started at age 5 and treated until the age of 7); 37 subjects were treated for one cycle of therapy per year for a total of five consecutive years (patients began at age 5, treated until the age of 9). Treated group of children is indicated as TG in the tables. Controls were represented by three untreated age-matched (5, 6, and 7 years old) groups of children selected by the same inclusion/exclusion criteria as mentioned above. These subjects are indicated as CG in the tables.

One cycle of standard therapy consisted of 12 consecutive days of Politzer insufflation, which is the commonly used procedure for spa water delivery in the upper respiratory airways of children. Standard Politzer techniques were used in our study [7,9]: Politzer inhalation exploits the deglutition movement when increased pressure in the rhino-faringeal cavity is created and it allows the ventilation of the Eustachian tube with a gaseous mixture until continuous flow is created, in a indirect manner, unlike direct endotympanic insufflation.

The test used to assess hearing status was a standard audiometry (10-60 dB scale) on the frequencies required for daily activities (500, 1,000, and 2,000 Hz) before and after a single cycle of therapy and was performed each time on both ears. We focused on air conduction, which is the focus of our study since the middle ear insufflation techniques exclusively act at the level of air conduction (see above exclusion criteria). Levels of deafness were evaluated at the above reported frequencies and auditory damage (in dB) was derived from the hearing loss registered at the different frequencies. Spa water used in this study contained sulphur ions as H_2S at a concentration of 18 mg/L.

Variance analysis was tested by ANOVA, whereas significant differences between groups were assessed by the Bonferroni test. All statistics were processed by Primers of Biostatistics ver. 4.02 (Health Professions Division, McGraw-Hill, Columbus, OH, USA).

RESULTS

During the course of therapy no adverse effects were reported and the procedure, which is minimally invasive, was always conducted with success and well tolerated. Bone transmission was always preserved as demonstrated by the values of the audiometry test (Table 1); alteration of bone transmission was nevertheless an exclusion criteria (see above in methods) and all the audiometry data was comparable among patients for the right and left ear with regards to bone transmission.

The cumulative results obtained by the cohort treated for three cycles of therapy (3 years) for the left ear (similar results were obtained for the right ear for all children, data not shown), show that dB loss at 500, 1,000, and 2,000 Hz invariably decreased at

Table 1. Distribution of hypoacusia among our patient cohort

Bone conduction	0.5 kHz		1.0 kHz		2.0 kHz	
	Acusia (dB)	Frequency (%)	Acusia (dB)	Frequency (%)	Acusia (dB)	Frequency (%)
TG (5 years) just before treatment	≤5	100	≤5	100	≤5	100
CG (6 years)	≤5	100	≤5	100	≤5	100
TG (6 years)+1 treatment	≤5	100	≤5	100	≤5	100
CG (7 years)	≤5	100	≤5	100	≤5	100
TG (7 years)+2 treatments	≤5	100	≤5	100	≤5	100

Bone transmission was examined for left ear (right ear results were comparable, and therefore are not shown) at three frequencies of stimulation. No patient (CG as well as TG) showed defects in bone transmission: hypoacusia values are comprised from 0 to 5 dB scale.
TG, treated group; CG, control group, untreated age-matched children.

Table 2. Distribution of hypoacusia among our patients cohort before and after therapy

	Acusia (dB) 0.5 kHz				Acusia (dB) 1.0 kHz				Acusia (dB) 2.0 kHz			
	Mean	SD	No	95%	Mean	SD	No	95%	Mean	SD	No	95%
TG (5 years) just before treatment	21.4	7.7	95	36.5	20.6	8.6	95	40	17.1	8.2	95	35
CG (6 years)	24.5*	7.5	112	37.3	22.7	8.7	112	40	17.7	7.5	112	30
TG (6 years)+1 treatment	18.1*,†	6.6	95	30	16.5*,†	6.9	95	31.5	13.1*	5.2	95	25
CG (7 years)	23.6	8.7	111	40	21.8	10.1	111	42.5	17.3	8.3	111	35
TG (7 years)+2 treatments	14.3*,†,‡	4.4	95	25	13.1*,†,‡	4.3	95	20	11*,‡	2.5	95	15

Means and 95th percentile are reported. Panels are representative of the left ear (right ear results were comparable, and therefore are not shown). Statistical analysis: ANOVA followed by Bonferroni test.
TG, treated group; CG, control group, untreated age-matched children.
*$P<0.05$ vs. TG just before treatment (5 years old children). †$P<0.05$ vs. CG (6 years old children). ‡$P<0.05$ vs. CG (7 years old children).

the end of the second cycle and even improved in the third cycle as compared with respective control groups (Table 2); horizontal bars (representing children numbers) become in fact consistently wider at the top of the dB scale (no or minimal dB loss) as the treatments were repeated. This trend is particularly evident at lower frequencies (500 Hz), where the hearing damage was more pronounced. The controls for six and seven year olds showed similar audiometric data consequent to the recruitment of children cohorts with similar deafness deficiency.

Moreover, when the therapy was prolonged (up to four treatments in 37 patients), almost no patients were left with significant hearing loss (Fig. 1), demonstrating: 1) the increasing efficacy of the therapy when repeated more than once, and 2) the stabilisation effect that occurs due to the reiterative approach. The levels of hypoacusia were more recorded at lower frequencies and the overall trend was toward a marked improvement of hearing perception.

DISCUSSION

Otitis media with effusion is an air conduction related deafness in children, particularly common under 8-10 years of age. Besides allowing drainage of secretions from the tympanic box, the middle ear is also responsible for pressure balance between inner and outer surfaces of the eardrum. In adults, chronic inflammatory conditions such as sinusitis, rhino-sinusitis and pharyngitis are the main causes of inflammation of the middle ear with effusion, while middle ear otitis is the most common cause of rhinogenic deafness and effusion in childhood. Therapy of chronic inflammatory conditions of the middle ear, which are responsible for hearing loss, poses some problems of long term pharmacological treatments. From this perspective, and considering the relatively uncertain efficacy of standard therapies, middle ear insufflation treatment with sulphur-rich mineral waters represents a consistent, long-term therapeutic option. Sulphur therapy has the well documented property [1-3,11,13] of reducing inflammation as well as restoring the physiological drainage and the micro-environment of the upper airways and the Eustachian tubes [7]. For centuries, the use of sulphuric waters and in general, of spa waters in some fields of therapeutic medicine has been based exclusively on an evidence-based approach, in the virtual absence of the scientific and experimental approach that validates all modern medical procedures [4]. Different types of spa waters (mostly of which contain sulphurs in various combinations with halogens or other ions), exert beneficial effects on human mucosal surfaces of the upper respiratory airways, and are normally administered by inhalation or aerosol [6-10]. Sulphurs are mucolytic and microbicidal and their actions include immune, anti-inflammatory and secretory mechanisms that are now well described. Consequently, several studies are now unravelling the molecular mechanisms that define the beneficial action of sulphuric waters [4,16].

Politzer inhalation (indirect ventilation of the middle ear) with

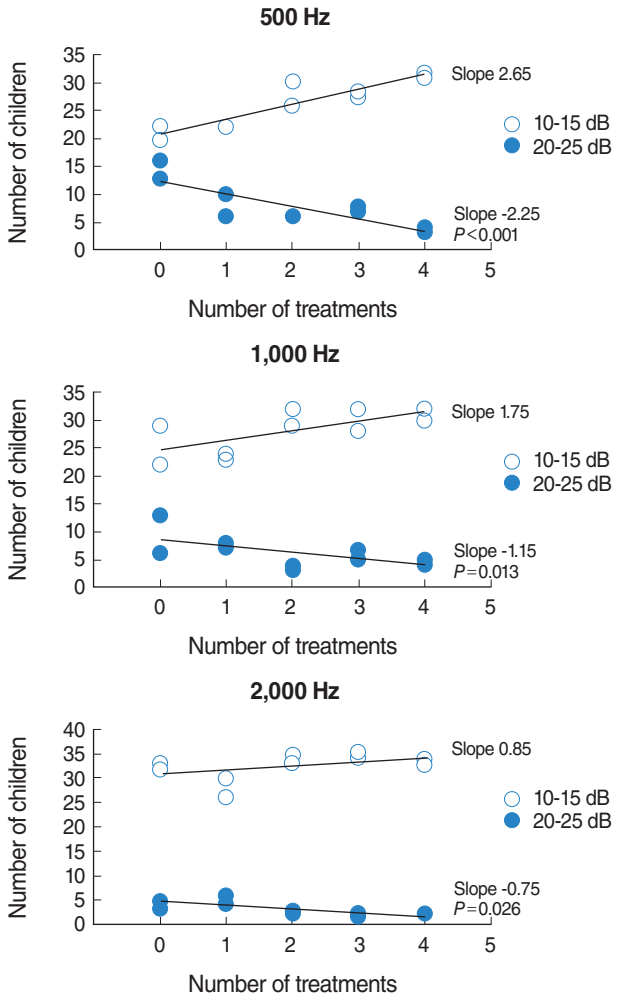

Fig. 1. Time-course of hearing levels (acusia) in a four-years follow-up of 37 patients. Hearing levels (right and left ear) are reported. Acusia values are arbitrarily clustered into two groups: 1) normal acusia-low hypoacusia group (below 15 dB of hearing loss, empty circles); 2) hypoacusia group (from 20 to 25 dB of hearing loss, filled circles). Linear correlation curves and slopes are reported. Note that at every frequency, but more evidently at 500 and 1,000 Hz, the three curves diverge ($P<0.001$, $P=0.013$, and $P=0.026$ for 500 Hz, 1,000 Hz, and 2,000 Hz curves, respectively) as the treatments increase in number. This indicates that progressively more children reach the normal hearing levels.

natural sulphur-rich water is therefore a common non-pharmacological treatment for children with otitis media with effusion. Audiometric measurements in our patients demonstrated an improved hearing function at the end of each therapeutic cycle, that stabilized over time. The mechanical effects of Politzer inhalation on the mucosae of the middle ear and Eustachian wall, as well as the action of the sulphurs on mucus consistency and fluidity are among the known factors that explain our results, that are similar to those obtained by adults [7-9].

Our data shows that patients' hearing always improves significantly at the end of each single therapeutic cycle (not shown). We believe that this effect could be more ascribed to the non-specific effects of therapy, like mechanical washing of the middle ear. However, the significant reduction of deafness registered at the beginning of each subsequent cycle (one year later), demonstrates a relevant stable therapeutic effect that increases in efficacy with cycle repetitions. Hearing deficit steadily decreased and virtually disappeared after 5 cycles. One caveat of our study is that this kind of pathology is often self-limiting and his natural course is very variable; thus we cannot link in a definitive manner the observed robust improvement of audiometric parameters solely with the chosen therapy. Moreover, we are aware that is limiting to explain our results with the use of spa therapy alone and undermine the significance of more traditional therapies that use endotympanic inhalation without spa waters.

In conclusions, we show that a well planned series of cycles of sulphur water Politzer inhalations of the middle ear ultimately resolve otitis media with effusion in children. We are aware that audiometry is considered an indirect and subjective test, whereas impedentiometry would be preferable as an objective assay. However, until now, most spa water medical centres use audiometry as a standard test, and consequently this was the data that we were able to assess in a retrospective study. Despite this caveat, our results indicate a significant effect on hearing function recovery of this non-pharmacological therapy for this common childhood pathology, that can be successfully conducted outside hospital settings.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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