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Evaluation of Efficiency of Magnesium Calcium Sulfate Mineral Water Kluchi for Treatment of Gastroduodenal Pathology in Children

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Abstract: The study deals with the potential of drinking magnesium calcium sulfate mineral water from the Kluchi health resort of the Russian Perm Territory in balneotherapy of gastroduodenal pathology in children. One hundred eight children from 6 to 16 years old suffering from non-Helicobacter pylori-related chronic gastroduodenitis were examined. The performed clinical, laboratory and instrumental tests demonstrated the efficiency of inclusion of the mineral water Kluchi into the complex therapy of gastroduodenitis in children. The optimal regimen of mineral water prescription at gastric hyperacidity was determined to be a dose of 5 mL per kg, temperature of 37°C, drinking 20 min before a meal and a 21-day course of administration. It was shown that the beneficial effect of using magnesium calcium sulfate mineral water Kluchi in combination with the basic therapy of chronic gastroduodenitis in children is caused by the alkalizing effect of mineral water, improvement of acid conditions in the gastric antrum, increase in the alkalization time, indicating a decrease in the acid production rate and has a beneficial effect on the clinical course of the disease by accelerating the regress of the key clinical symptoms. The results of the set of clinical investigations confirm from the scientific standpoint the efficiency of magnesium calcium sulfate mineral water of the Kluchi health resort against gastroduodenal pathology in children and allow for broad recommendation of this water in the complex therapy of chronic inflammatory diseases of the gastroduodenal zone in children.

Key words: Children · Gastroduodenitis · Therapy · Magnesium calcium sulfate mineral water

INTRODUCTION

The Perm Territory is among the most abundant in mineral water reserves. The Kluchi health resort founded back in 1826 is widely known in Russia; one of natural therapeutic factors of the resort is mineral drinking balneotherapy. The curing properties of one of the Kluchi sources for digestive tract diseases were noted almost 200 years ago.

The recent studies of the physicochemical properties of this water (test certificate no. 11/01/494/1/1 of 7.05.2001 of the Department of health resort resources of the Yekaterinburg Medical Research Centre and test certificate No. 1106/281 of 27.04.2001 of Sverdlovsk Regional Sanitary and Epidemiological Supervision Center) demonstrated that the key chemical composition, biologically active elements and micronutrients of this water correspond to the requirements established for medicinal-and-table drinking mineral waters.

Thus, according to GOST 13273-88 "Drinking medicinal and medicinal-table mineral waters. Specifications", water being considered corresponds to Smolensk type magnesium calcium sulfate waters, being weakly alkaline and medium-mineralized. The presence of calcium in water stimulates regeneration processes, magnesium ions stimulate the formation of tissue hormones, catalyze trypsin and erepsin and exert a spasmolytic action on the gallbladder and the Oddi's sphincter. Sulfate ions regulate the motor function of the gastrointestinal tract and have a bile-expelling effect.

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Table 1: Chemical composition of water from well no. 1/92 of the Kluchi health resort (per liter of water)

Mineral composition	Gram (g)	Mg-eq.	Eq. %
Cations:			
Potassium (K^+)	0.234	-	18.00
Sodium (Na^+)	0.168		18.00
Magnesium (Mg^{2+})	0.666		24.00
Calcium ($Cà^{2+}$)	0.422	21.10	57.90
Sum of cations		100.00	
Anions:			
Chlorine ($C1^-$)	0.122		6.00
Sulfates (SO_4^{2-})	2.228		81.00
Hydrogen carbonates ($ÍCÎç^-$)	0.458		13.00
Iodine (I^-)	0.0003		
Bromine (Br^-)	0.001		
Sum of anions			100.00
Non-dissociated molecules (mg/L):			
Bromine (Br^-)	1.07		
Orthoboric acid ($Í_3ÂO_3$)	14.87		
Metasilicic acid (H_2SiO_3)	19.19		
Iron (Fe)	0.05		
Organic compounds (C_{org})	0.11		
Total mineralization 2.99 g/L			

Kurlov's formula:

$$M\ 2.99\ \frac{SO_4 81 HCO_3 13 CL6}{Ca58 Mg24(Na+K)18}\ pH\ 7{,}72,\ T-6°C$$

When combined with calcium cations, sulfate ions decrease the inflammatory conditions in the gastrointestinal tract and activate the recovery processes in the gastric mucosa. Attention is drawn by the presence of orthoboric acid, which enhances the antacid effect of water (together with bicarbonates) and metasilicic acid, which is a source of easily absorbable silicon; also, it has an anti-inflammatory action and retarding action on the secretory function of the stomach. All this provides for the wide use of this water to treat gastro-intestinal tract diseases [1,2,3]. However, no profound experimental clinical research of the efficiency of this water in the therapy of gastric diseases in children was carried out and this determined the purpose of the work: study of the effect of the Mineral water Kluchi on the acid-forming function of the stomach, development of the optimal regimen of water intake and clinical evaluation of its efficiency in threating the gastroduodenal pathology in children.

MATERIALS AND METHODS

The research was performed on 108 children (56 girls and 52 boys) from 6 to 16 years old with non-Helicobacter pylori-related chronic gastroduodenitis; the average age was 13.04 ± 2.3 years.

The patients were subjected to complete clinical and laboratory examination including medical history, in particular, the frequency of acute respiratory infections and other diseases against which children had long (in some cases, disorderly) been given non-steroidal anti-inflammatory drugs (NSAIDs), which may be responsible for the damage of gastric mucosa. The complaints, the character of onset of the disease, the presence of the accompanying pathology both in the gastrointestinal tract and in other systems were analyzed. The general status of the children was estimated and symptoms related to the damage of the gastrointestinal tract were revealed. Standard laboratory and biochemical tests, enzyme immunoassay and helic-test for Helicobacter pylori and sonographic examination of digestive organs were carried out. Other procedures included dynamic endoscopic examination of the gastroduodenal mucosa, investigation of the biopsy materials from the gastric fundus and antrum, intragastric pH-metry, gastric juice acidity (pH) determination.

The investigation had parallel design; it was simple, open and controlled. According to the goals and objectives set, children suffering from non-Helicobacter pylori-related chronic gastroduodenitis were divided into two groups in accordance with the therapy protocol:

1st group (basic) comprised 70 patients who received complex therapy including the mineral water Kluchi and the basic therapy consisting of a dietary regimen, an antacid drug and, if necessary, motilium and sedative medications.

2st group (reference) comprised 38 patients receiving only the basic therapy.

Eligibility Criteria Included: clinical findings, type of endoscopically observed changes in the gastroduodenal mucosa (no erosive or ulcer changes), gastric juice pH, the absence of Helicobacter pylori according to enzyme immunoassay and helic test data.

The groups were formed using both random selection and typology (the balanced group method), taking account of the age, gender and severity of the disease ($p>0,05$).

The results were statistically treated using the Microsoft Excel program and Biostat program package. The statistical treatment included calculation of the arithmetic mean and the standard error of the mean. The two samplings were compared using the Student criterion. The critical significance level of differences was taken to be $p<0.05$.

RESULTS

The chronic gastroduodenitis in the children in question was, most often, recurrent, characterized by progression of key symptoms and involvement of the adjacent digestive organs into the pathological process. Recurrences were often associated with respiratory infections that were treated using NSAIDs, which are known to have adverse effect on the gastric mucosa, giving rise to NSAID-induced gastropathy [7,8,9,10]. The key clinical manifestations of the disease comprised the abdominal pain syndrome with pain location in the epigastric and pyloroduodenic areas and the dyspeptic and astheno-vegetative syndromes. Also, the vast majority of the children had micronutrient deficiency symptoms: skin pallor and xeroderma, angular stomatitis, cheilitis, enhanced brittleness of nails and hair, lateral and longitudinal nail banding, general weakness, loss of appetite, rapid fatigability. According to pH-metry, in 33.4% of cases, chronic gastroduodenitis was accompanied by enhanced acid forming function of the stomach.

In the histologic examination of the gastric mucosa, attention was paid to the presence of dystrophic changes of the superficial-foveolar epithelium (in particular, hyperchromia and increase in the size of nuclei of epithelial cells), the presence of necrosis areas or desquamation of epithelial cells from the mucosa surface, capillary expansion in the mucosa lamina propria, hypertrophy of smooth-muscle elements, character of mucin secretion from the epithelial cells of gastric mucosa, the presence and the degree of inflammatory infiltration in the lamina propria of gastric mucosa and the presence of *Helicobacter pylori* in the biopsy material.

Microscopic examination of gastric mucosa specimens showed, in 77.1% of patients, statistically significant more often occurrence of the histological indications of NSAID-induced gastropathy: the absence of inflammation, identification of mucin in cytoplasm, fibrous degeneration of the lamina propria of gastric mucosa [5,6].

In 22.9 % of the children, histological examination of gastric mucosa specimens revealed the presence of *Helicobacter pylori* bodies, despite the fact that laboratory tests (enzyme immunoassay and helic test) did not reveal *Helicobacter pylori* and the patients were considered to be HP-negative. In these biopsy materials, histological indications of type B gastritis such as pronounced inflammatory infiltration and mucin hypersecretion from the superficial-foveolar epithelium cells were identified with statistically significant higher frequency.

Since no profound research of the efficiency of the mineral water Kluchi against gastroduodenal pathology in children or substantiation of the therapy regimens was performed previously, the mineral water being used empirically, we developed an optimal regimen for administration of the mineral water Kluchi to gastroduodenal pathology children, although regimens of using mineral waters in patients with gastrointestinal tract pathology can be found in the literature. After that, we evaluated the efficiency of inclusion of the water into the complex therapy of this pathology.

The optimal dose of the mineral water Kluchi was selected proceeding from the fact that the recommended single-shot dose of mineral water is 3-3.2 mL per kg of body weight (methodical guidelines, St. Petersburg, 2006). The clinical tests (acute pH-metry) demonstrated that the most pronounced alkalizing effect is achieved when the water Kluchi is taken in the dose of 5 mL per kg; therefore, we took this amount as optimal (Table 2).

The next stage was to select the optimal temperature conditions. For this purpose, we studied the effect of the water Kluchi after a single-shot administration in a 5 mL per kg dose at different temperatures on the pH. The highest maximum pH values, DpH, (i.e., the most pronounced alkalizing effect) were noted upon taking water at a temperature of 37°C in a dose of 5 mL per kg of body weight and, hence, this was considered to be optimal for treatment of children with preserved or moderately elevated gastric acidity (Table 3).

Table 2: Effect of single-shit administration of the mineral water Kluchi in different doses on the basal phase pH values in the gastric corpus at a temperature of 37°C

	Dose			
Intake regimen	1 mL/kg n=6	3 mL/kg n=14	5 mL/kg n=16	P
Max corpus pH Response time (min)	No response	2.76±0.18	6.48±0.22	p<0.01
	No response	6.2±1.78	17±3.5	p<0.01

Table 3: Effect of single administration of the mineral water Kluchi in 5 mL/kg dose on the gastric pH values at different temperatures

	Temperature			
Regimen of administration	23°C n=14 (gr. 1)	37°C n=16 (gr. 2)	45°C n=12 (gr. 3.)	P
Maximum corpus pH level	3.06±0.15	6.48±0.22	6.2±0.14	$P^1/_2$<0.01 $P^1/ç$<0.01 $p^2/ç$>0.1
DpH	1.3±0.12	4.9±0.18	4.7±0.14	$p^1/_2$<0.01 $p^1/ç$<0.01 $p^2/ç$>0.05
Response time (min)	9.1±3.43	17±3.5	18.9±3.1	$p^1/_2$<0.01 $p^1/ç$<0.01 $p^2/ç$>0.05
Maximum antrum pH level	7.0	7.5	7.34	$p^1/_2$<0.01 $p^1/ç$<0.01 $p^2/ç$>0.05

The total time of pH increase in the gastric corpus pH was 17+ minutes.

Furthermore, a substantial increase in the basal pH level after a single-shot intake of the water Kluchi was found in the gastric antrum, which was also most pronounced when 5 mL of water per kg of body weight was taken at 37°C. This is of paramount clinical importance, as alkalization of the antrum and the duodenum mitigates the acid peptic aggression and creates favorable conditions for improvement of tropism and reparative activity.

According to the presented results, after a single-shot administration of the water Kluchi at 37°C, the initial pH level is almost restored, which confirms the above data about the expediency of using the water Kluchi in children with gastroduodenitis.

Thus, the investigation of mineral water effect on the variation of the gastric pH level by "acute observations" (single-shot administration of water in a dose of 5 mL per kg at different temperatures) demonstrated that the optimal regimen of taking the Kluchi water at normally acidic and moderately hyperacidic state of stomach comprises temperature of 37°C, dose of 5 mL/kg and time instant of 20 minutes before a meal.

The foregoing allowed for substantiation of a course of using the water Kluchi in children with chronic gastroduodenitis with preserved and enhanced acid-forming function.

As noted above, the children were divided into two groups:

Basic group (70 children) received the basic therapy and the mineral water Kluchi.

Reference group (38 children) received only the basic therapy.

The course of using mineral water laster, on average, for 3 weeks.

A key criterion of the efficiency of the therapy of gastroduodenitis is elimination of the pain syndrome, which adversely affects not only the overall health of the patient and learning performance but also the functional state of the body systems. When the children were admitted to the hospital, pain syndrome was guiding in the clinical presentation of all children. During the therapy, the pain syndrome was stopped in all patients mainly on the 2nd to 7th day of the therapy. In the group of children that were given the water Kluchi apart from the basic therapy, the average period of pain syndrome elimination was 4.6±2.3 days, while for children of the reference group who took only the basic therapy, this period was 6.1±3.3 days ($p<0.01$).

Upon the therapy, dyspeptic disorders in the test group stopped much faster than the pain syndrome. In 82.8% of children, dyspeptic symptoms stopped on the 1st to 4th day of therapy, the average period was 3.1 ± 1.9 days.

In the reference group, the therapeutic effect with respect to the dyspeptic syndrome was also achieved, the symptoms being eliminated in all patients. The regression of dyspeptic disorders occurred on the 1st to 4th day of therapy for 84.2% of the children, the average period to elimination being 3.1±1.8 days ($p>0.05$). The palpatory pain disappeared, on average, on the 7.2 ± 2.6 day of the therapy in the test group and after 8.4 ± 3.9 days in the reference group ($p >0.05$).

An important criterion for the efficiency of therapy is the variation of the acid-forming function of the stomach. The pH-metry carried out after the therapy demonstrated that the course therapy including the water Kluchi had a beneficial effect on the gastric acidity, which was

Table 4: Averaged pH values in the gastric corpus before and after the course therapy involving the water Kluchi (n=58)

Stomach acidity	pH-before the therapy n=58	pH-after the therapy n=58	P
pH max.	1.67±0.05	2.12±0.07	P<0.01
pH min.	1.5±0.06	1.83±0.04	P<0.01
pH aver.	1.58±0.04	1.92±0.06	P<0.01

The decrease in the acidity of the stomach content, according to A. M. Zaprudny data (1998), provides for elimination of the pain syndrome, as acidification of the stomach medium is considered to be a significant factor in the pain pathogenesis.

Table 5: Averaged pH values in the gastric antrum before and after the course therapy involving the water Kluchi (n=58)

Antrum pH values	pH-before the therapy n=58	pH-after the therapy n=58	P
pH max.	6.8±0.26	7.12±0.15	p>0.05
pH min.	6.2±0.23	6.4±0.17	p>0.05
pH aver.	6.52±0.23	6.8±0.15	p>0.05
Alkaline time	9.87 min.±0.96	17.33 min.±0.92.	P<0.01

manifested as a statistically significant increase in the maximum, minimum and average basal pH values in the gastric corpus (Table 4).

The decrease in the acidity of the stomach content, according to A. M. Zaprudny data (1998), provides for elimination of the pain syndrome, as acidification of the stomach medium is considered to be a significant factor in the pain pathogenesis.

The antrum pH values also tended to improve and the alkaline time increased almost twofold after the course of therapy (Table 5).

In the opinion of R.N.Yamoldinov (2003), an increase in the basal pH values in the gastric antrum is important, as alkalization of the gastric antrum and duodenum mitigates the acid peptic aggression and creates favorable conditions for improvement of trophism and reparative activity.

CONCLUSION

Thus, the performed research demonstrated the efficiency of inclusion of the mineral water Kluchi in the complex therapy of the hyperacid and normally-acidic syndrome in children. The inclusion of the mineral water Kluchi in the complex therapy of gastroduodenitis in children has a beneficial effect on the clinical course of the disease by accelerating the regress of the key clinical symptoms. The beneficial effect of the application of magnesium calcium sulfate water Kluchi in combination with the basic therapy in children with chronic gastroduodenitis is caused by the alkalizing effect of the mineral water, improvement of the acidity characteristics in the stomach antrum, increase in the alkalization time, which attests to a decrease in the acid formation rate.

The results of the set of clinical investigations confirm, from the scientific standpoint, the efficiency of the mineral water Kluchi for gastroduodenal pathology in children and allow for broad recommendation of magnesium calcium sulfate mineral water from the Perm health resort Kluchi in the complex therapy of chronic inflammatory diseases of the gastroduodenal zone in children.

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