

CHLORINE CONCENTRATION IN CHILDREN'S SWEAT TEST

Danielius Serapinas^{1,2}, Mantas Sauspreskis¹, Justinas Žiūraitis¹, Diana Barkauskienė¹,
Marius Žemaitis¹, Raimundas Sakalauskas¹

¹*Department of Pulmonology and Immunology, Medical Academy, Lithuanian University of Health Sciences, ²Mykolas Romeris University*

Key words: health, chlorine concentration, child.

Summary

It is essential to confirm or exclude the diagnosis of cystic fibrosis in time and with accuracy in order to avoid inappropriate testing. The aims of this study was to determine features of Cl ions concentration in patients sweat test that were suspected having cystic fibrosis and to evaluate correlation between this concentration and C reactive protein levels in serum. Results showed, that 9 out of 48 patients (18,75 %) showed higher than normal Cl ions concentration values. 6 of them (12,5%) had a borderline concentration, while 3 (6,25%) were positive according to Cl ions concentration test. Mean value of Cl ions concentration in males sweat was 25,37 mmol/l ($p < 0,05$; PI=21,05-30,40) and there was no statistical significance compared to mean Cl ions concentration in females sweat which was 24,44 mmol/l ($p < 0,05$; PI=19,96-28,91). All genetic tests' results were negative for CFTR gene mutations. CRP test was performed in 17 cases (35,42%). No statistically significant correlation between concentration of Cl ions in sweat and serum CRP was found ($r = -0,16$; $p = 0,531$). No statistically significant difference between Cl ions concentrations in sweat test according to gender was found in examined group. In our study no mutations of CFTR gene were found. Statistically significant correlation between Cl ions concentration in sweat test and serum CRP level was not found.

Introduction

Cystic fibrosis is autosomal recessive genetic disorder affecting function of exocrine glands. Most often lower respiratory tract, pancreas and sweat glands are affected. As a result of this disorder, sodium and chlorine concentrations increase in patients sweat. Sweat test plays mayor

role in diagnosing cystic fibrosis. It is essential to confirm or exclude the diagnosis of cystic fibrosis in time and with accuracy in order to avoid inappropriate testing [1]. Last year an article was published which revealed that some blood biomarkers can be useful to estimate the activity of cystic fibrosis and to predict pulmonary exacerbations. It was shown that C-reactive protein test has the most potential in clinical usage when the diagnosis of cystic fibrosis is present [2,3]. Furthermore, it is now known that lung function impairment was independently associated with elevated plasma levels of CRP [3,4]. One of our aims was to determine whether increase in CRP could predict the onset of cystic fibrosis symptoms, when clinicians suspect cystic fibrosis.

Aims of this study was to determine features of Cl ions concentration in patients sweat test that were suspected having cystic fibrosis and to evaluate correlation between this concentration and C reactive protein levels in serum.

Methods

We investigated retrospectively case files of patients with performed sweat test in period of 2011-2012 in Hospital of Lithuanian University of Health Sciences Kauno Clinic's Paediatrics department. These patients were suspected having cystic fibrosis ($n = 48$). Results of Cl ions concentration in sweat test, information about genetic testing of cystic fibrosis transmembrane conductance regulator (CFTR) gene's mutations and levels of C reactive protein (CRP) were used in our study. Cl ions concentration in sweat test is borderline if results are between 40-60 mmol/l, positive – if exceeds 60 mmol/l concentration in sweat. CRP is positive if exceeds 5 mg/l. Data were processed using SPSS v15 statistical software. Statistical significance is $p < 0,05$. Correlation between CRP and Cl ions concentration in sweat test was evaluated using Pearson's correlation coefficient.

Results and discussion

Our studied group was comprised of 48 patients, 30 of

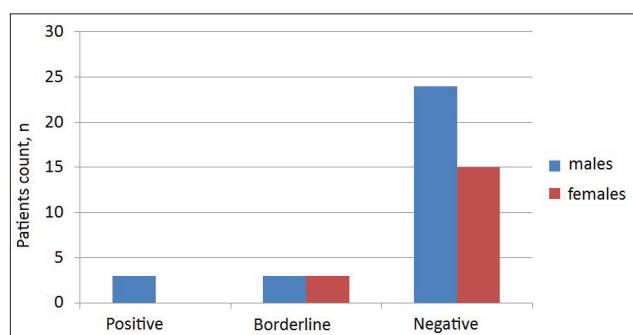


Figure 1. Cl ions concentration in sweat test

them were males, while 18 were females. Mean age when first symptoms occurred was $3,8 \pm 3,1$ years for males and $3,0 \pm 3,1$ years for females. First symptoms predominantly indicated respiratory tract lesions – 47 (97,9%) patients. 1 patient had only gastrointestinal tract symptoms, 3 had both respiratory tract and gastrointestinal tract symptoms. 9 out of 48 patients (18,75 %), who had been tested for sweat Cl ions concentration, showed higher than normal concentration values. 6 of them (12,5%) had a borderline concentration, while 3 (6,25%) were positive according to Cl ions concentration test (Figure 1). 3 patients (50%) who had a borderline increase were males and 3 patients (50%) were females. All patients with positive test results were males. Mean value of Cl ions concentration in males sweat was 25,37 mmol/l ($p < 0,05$; PI=21,05-30,40) and there was no statistical significance compared to mean Cl ions concentration in females sweat which was 24,44 mmol/l ($p < 0,05$; PI=19,96-28,91). All patients who were positive for Cl ions concentration in sweat test and one patient with borderline increase were tested genetically for mutations of CFTR gene. All genetic tests' results were negative for CFTR gene mutations. CRP test was performed in 17 cases (35,42%). The mean value was $32,31 \pm 73,68$ mg/l. 13 patients (82,35%) had an increase in serum CRP. No statistically significant correlation between concentration of Cl ions in sweat and serum CRP was found ($r = -0,16$; $p = 0,531$) (Figure 2). The reference ranges for normal sweat osmolality are 50–150 mmol/kg, and values greater than 200 mmol/kg are consistent with CF [4- 8]. Borderline values are considered to be between 150–200 mmol/kg by some authors [9-10], others are considering values < 170 mmol/kg as normal [9]. Measuring osmolality can help as a screening method but it is not recommended for the diagnosis of CF [11-15]. Conductivity is the property of a solution that allows it to conduct a current. It depends on the concentration and mobility of the ions in the solution, and is therefore an indirect measurement of ions [16]. Sweat

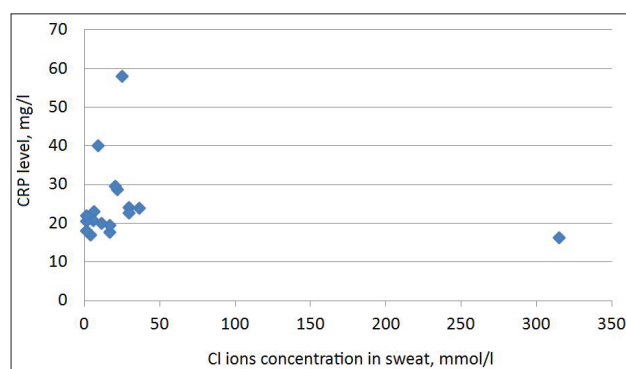


Figure 2. Pearson's correlation between Cl concentration in sweat and CRP in serum

conductivity is not equivalent to sweat chloride concentration because of other ions in sweat such as bicarbonate and lactate, therefore sweat conductivity is approximately 15 mmol/L higher than the sweat chloride concentration [14]. According to the American CF Foundation, a conductivity value less than 50 mmol/L is considered normal and patients with values > 50 mmol/L should be referred for a quantitative pilocarpine iontophoresis test (QPIT) [17]. A conductivity level > 80 mmol/L is believed to be diagnostic in addition to its screening value by some authors [18-25], while others suggest values > 90 mmol/L to support a diagnosis of CF [26]. The UK guidelines recommend that a sweat test can be performed after 2 weeks of age in infants > 3 kg [27], whereby others suppose that sweat collection can be reliably performed in infants > 36 weeks postmenstrual age, > 2 kg, and > 3 days postnatal age [16]. Sweat testing should not be performed before a child is at least 48 hours old, as in the first 24 hours after birth, a baby's sweat electrolyte concentrations are known to rise transiently [28-30]. A sweat test should always be delayed in children who are dehydrated, systemically unwell or who have eczema affecting the potential stimulation sites, or who are oedematous and/or on systemic corticosteroids [14]. In addition, many other diseases can lead to false-positive and false-negative results which is described in detail elsewhere [1,16].

Conclusions

18,75% of checked patients had a higher than normal Cl ions concentration in sweat. No statistically significant difference between Cl ions concentrations in sweat according to gender was found in examined group. 33,33% of patients who had Cl ions concentration in sweat above normal range were females and 66,66% were males. Genetic testing is performed usually only when the Cl ions concentration

test in sweat is positive. In our study no mutation of CFTR gene were found and therefore no correlation between mutations of CFTR gene and chlorine concentration in sweat was found.

Acknowledgements

This article was possible with support from family clinic Alfa Clinic and Vilnius city municipality administration project for community health promotion.

References

- Davis PB. Cystic fibrosis since 1938. *Am J Resp Crit Care Med* 2006;173:475–8.
- Shoki AH, Mayer-Hamblett N, Wilcox PG. Systematic review of blood biomarkers in cystic fibrosis pulmonary exacerbations. *Chest* 2013;144:1659-70.
- Mackay R, George P, Kirk J. Sweat testing for cystic fibrosis: A review of New Zealand laboratories. *J Paediatr Child Health* 2006;42:160–4.
- Massie J, Clements B, Australian Paediatric Respiratory Group. Diagnosis of cystic fibrosis after newborn screening: the Australian experience – twenty years and five million babies later: a consensus statement from the Australian Paediatric Respiratory Group. *Pediatr Pulmonol* 2005;39:440–6.
- Bush A, Wallis C. Time to think again: Cystic fibrosis is not an “all or none” disease. *Pediatr Pulmonol.* 2000;30:139–44.
- De Boeck K, Wilschanski M, Castellani C, Taylor C, Cuppens H, Dodge J, et al. Cystic fibrosis: terminology and diagnostic algorithms. *Thorax* 2006;61:627–35.
- Knowles M, Durie P. What is cystic fibrosis? *N Engl J Med* 2002;347:439–42.
- di Sant’Agnese PA, Darling RC, Perera GA, Shea E. Abnormal electrolyte composition of sweat in cystic fibrosis of the pancreas: clinical significance and relationship to the disease. *Pediatrics* 1953;12:549–63.
- Gibson LE, Cooke RE. A test for concentration of electrolytes in sweat in cystic fibrosis of the pancreas utilizing pilocarpine by iontophoresis. *Pediatrics* 1959;23:545–9.
- Carter EP, Barrett AD, Heeley AF, Kuzemko JA. Improved sweat test method for the diagnosis of cystic fibrosis. *Arch Dis Child* 1984;59:919–22.
- LeGrys VA. Assessing quality assurance for sweat chloride testing. *Clin Lab Sci.* 1992;5:354–7.
- Mastella G, Di Cesare G, Borruso A, Menin L, Zanolla L. Reliability of sweat-testing by the Macroduct collection method combined with conductivity analysis in comparison with the classic Gibson and Cooke technique. *Acta Paediatr* 2000;89: 933–7.
- Barben J, Ammann RA, Metlagel A, Schöni MH. Conductivity determined by a new sweat analyzer compared with chloride concentrations for the diagnosis of cystic fibrosis. *J Pediatr* 2005;146:183–8.
- Hammond KB, Nelson L, Gibson LE. Clinical evaluation of the macroduct sweat collection system and conductivity analyzer in the diagnosis of cystic fibrosis. *J Pediatr* 1994;124:255–60.
- Heeley ME, Woolf DA, Heeley AF. Indirect measurements of sweat electrolyte concentration in the laboratory diagnosis of cystic fibrosis. *Arch Dis Child* 2000;82:420–4.
- Beauchamp M, Lands LC. Sweat-testing: A review of current technical requirements. *Pediatr Pulmonol* 2005;39:507–11.
- Quinton PM. Physiological basis of cystic fibrosis: a historic perspective. *Physiol Rev* 1999; 79:S3-22.
- Sheppard DN, Welsh MJ. Structure and function of the CFTR chloride channel. *Physiol Rev* 1999; 79:S23-45.
- Kopelman H, Corey M, Gaskin K, Durie P, Weizman Z, Forstner G. Impaired chloride secretion, as well as bicarbonate secretion, underlies the fluid secretory defect in the cystic fibrosis pancreas. *Gastroenterology* 1988; 95:349-55.
- Quinton PM, Reddy MM. CFTR, a rectifying, non-rectifying anion channel? *J Korean Med Sci* 2000; 15:S17-20.
- Sohma Y, Gray MA, Imai Y, Argent BE. HCO₃⁻ transport in a mathematical model of the pancreatic ductal epithelium. *J Membr Biol* 2000; 176:77-100.
- Reddy MM, Quinton PM. HCO₃⁻ impermeability via CFTR-Cl conductance in sweat duct. *Pediatr. Pulmonol Suppl* 1993; 9:208.
- Linsdell P, Tabcharani JA, Rommens JM, Hou YX, Chang XB, Tsui LC. et al. Permeability of wild-type and mutant cystic fibrosis transmembrane conductance regulator channels to polyatomic anions. *J Gen Physiol* 1997; 110:335-64.
- Poulsen JH, Fischer H, Illek B, Machen TE. Bicarbonate conductance and pH regulatory capability of cystic fibrosis transmembrane conductance regulator. *Proc Natl Acad Sci USA* 1995; 91:5340-4.
- Singh M, Krouse M, Moon S, Wine JJ. Most basal I(SC) in Calu-3 human airway cells is bicarbonate-dependent Cl⁻ secretion. *Am J Physiol* 1997; 272:L690-8.
- Anderson MP, Sheppard DN, Berger HA, Welsh MJ. Chloride channels in the apical membrane of normal and cystic fibrosis airway and intestinal epithelia. *Am J Physiol* 1992; 263: L1-14.
- Reddy MM, Quinton PM. Hydrolytic and nonhydrolytic interactions in the ATP regulation of CFTR Cl⁻ conductance. *Am J Physiol* 1996; 271:C35-42.
- Choi JY, Muallem D, Kiseyov K, Lee MG, Thomas PJ, Muallem S. Cystic fibrosis severity correlates with aberrant CFTR dependent HCO₃⁻ transport. *Nature* 2001; 410:94-7. [More details]
- Reddy MM, Light MJ, Quinton PM. Activation of the epithelial Na⁺ channel (ENaC) requires CFTR Cl⁻ channel function. *Nature* 1999, 402:301-04.
- Quinton PM, Reddy MM. Control of CFTR chloride conductance by ATP levels through non-hydrolytic binding. *Nature* 1993; 360:79-81.

CHLORO KONCENTRACIJOS YPATUMAI**VAIKŲ PRAKAITO TYRIME****D. Serapinas, M. Sauspreskis, J. Žiūraitis, D. Barkauskienė,
M. Žemaitis, R. Sakalauskas**

Raktažodžiai: sveikata, chloro kiekis, vaikas.

Santrauka

Chloro kiekis dažnai būna padidėjęs esant cistinės fibrozės diagnozei, tačiau esant lėtinėms kvėpavimo takų ligoms chloro kiekis prakaito gali būti labai įvairus. Tyrimo tikslas nustatyti chloro koncentracijos prakaito ypatumus įtariant cistinę fibrozę. Metodika. Atrinktos istorijos pacientų, kuriems 2011-2012 metais buvo darytas chloro koncentracijos tyrimas įtariant cistinę fibrozę (n=48). Iš ligos istorijų surinkta chloro koncentracijos prakaito tyrimo rezultatai, duomenys apie genetinius cistinės fibrozės transmembranių laidumą reguliuojančio baltymo koduojančio geno (CFTR) mutacijų tyrimus, bei C reaktyvaus baltymo (CRB) reikšmės. Chloro koncentracijos prakaito mėginys laikomas abejotinu, jei gauti rezultatai yra 40-60 mmol/l intervale, ir teigiamu, jei >60 mmol/l. CRB laikomas padidėjusiu, jei jo kiekis serume viršija 5mg/l. Gauti duomenys apdoroti SPSS v15 paketu. Reikšmingumo lygmuo pasirinktas $p < 0,05$. Sąsajos tarp CRB ir Cl koncentracijos prakaito tikrintos Pearson' o koreliacijos koeficientu. Rezultatai. Iš 48 pacientų, kuriems buvo tirta chloro koncentracija prakaito, 9 (18,75%) nustatytos norma viršijančios reikšmės.

6 (12,5%) iš jų nustatytas abejotinas padidėjimas, 3(6,25%) - teigiamas chloro koncentracijos mėginys. 3(50%) pacientai su abejotinu mėginiu yra vyriškosios lyties, 3 (50%) – moteriškosios. Visi pacientai su teigiamu mėginiu yra vyriškosios lyties. Vidutinis chloro koncentracijos kiekis vyriškosios lyties tiriamųjų prakaito 25,73mmol/l ($p < 0,05$; PI=21,05-30,40) statistiškai reikšmingai nesiskyrė nuo moteriškosios lyties tiriamųjų 24,44 mmol/l ($p < 0,05$; PI=19,96-28,91). Visiems pacientams su teigiamu chloro koncentracijos prakaito mėginiu bei vienam su abejotinu atlikti genetiniai CFTR geno mutacijų tyrimai. Visų tyrimų rezultatai neigiami. CRB tyrimas atliktas 17 (35,42%) pacientų, vidutinė reikšmė 32,31±73,68 mg/l. 13pacientų (82,35%) CRB kiekis serume buvo padidėjęs. Statistiškai reikšmingos koreliacijos tarp chloro koncentracijos prakaito ir CRB serume nenustatyta ($r = -0,16$; $p = 0,531$). Gautos išvados parodė, kad genetinis tyrimas atliekamas tik nustačius teigiamą chloro koncentracijos prakaito mėginį, tačiau tyrimo metu mutacijų nustatyta nebuvo ir sąsajų tarp CFTR geno mutacijų ir chloro koncentracijos prakaito nenustatyta. Statistiškai reikšmingos koreliacijos tarp chloro koncentracijos prakaito ir CRB serume nenustatyta ($p > 0,05$).

Adresas susirašinėti: dserapinas@gmail.com

Gauta 2015-01-26