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S. NOSAL[1], P. DURDIK[1], M. SUTOVSKA[2], S. FRANOVA[2], V. NOSAL[3], J. KOPPL[4], J. HAMZIK[5], P. BANOVCIN[1]

CHANGES OF AIRWAY OBSTRUCTION PARAMETERS IN HEALTHY CHILDREN CAUSED BY MOTHER'S SMOKING DURING PREGNANCY

[1]Pediatric Clinic, [2]Department of Pharmacology, and [3]Neurology Clinic, Jessenius Faculty of Medicine, Comenius University, Martin, Slovakia; [4]Pediatric Clinic of Anesthesiology and Intensive Care, Children Hospital, Bratislava, Slovakia; [5]Department of Surgery, Comenius University in Bratislava, Jessenius Faculty of Medicine, Martin, Slovakia

The present study was aimed at the assessment of the impact of mother smoking during pregnancy on changes of phase angle (φ) and T_{me}/T_E index in healthy children. A hundred and twenty seven children, divided according to age (<6 months and >6 months of age) and mother smoking anamnesis were investigated by noncalibrated respiratory inductive plethysmography in the supine position. We found statistically significant changes of φ ($p<0.05$) and T_{me}/T_E in healthy children of non-smoking mothers against a group of smoking mother's children of up to 6 months of age. These differences were not confirmed in children older than 6 months. Moreover, in the smoking mother group, we found statistically significant changes ($P<0.05$) of φ and T_{me}/T_E in children of up to 6 months of age in comparison with children older than 6 month. The results revealed a negative impact of mother smoking during pregnancy represented by changes in airway obstruction parameters, which appeared especially in the group of youngest children.

Key words: *children, phase angle, pulmonary function, respiratory inductive plethysmography, smoking*

INTRODUCTION

It is well known that smoking, both active and passive, seriously damages human health (1, 2). The growth and development of a child are influenced by many innate and acquired factors, both postnatally and prenatally. Substantial

development and functional changes may occur as early as during intrauterine evolution and subsequently may have impact on the quality of an individual life.

According to many literature data, it is clear that children of smoking mothers during their pregnancy are prone to a higher incidence of respiratory system disorders. The vasoactive substances, e.g., NO and nicotine, in the mother's body are one of the main initiating or triggering factors of respiratory diseases (3-5). Disorders of the respiratory system have a leading position in morbidity and mortality of contemporary populations. It is known that the incidence of respiratory illness in childhood and later in adult life depends on whether they occurred in the first year of life (6-8). It is thus clear that an early treatment of functional respiratory abnormalities in childhood represents an effective remedy for the occurrence of respiratory disorders later in life. The investigation of pulmonary functions in non-cooperative pediatric patients is still complicated. The non-calibrated respiratory inductive plethysmography (Respitrace) is one of method helping to examine non-cooperative small children.

The principle of respiratory inductive plethysmography is based on the measurement of time-dependent changes of the extent of movement in the rib cage and abdominal musculature during breathing. Volume changes are recorded as rib cage and abdominal curves, from which it is possible to determine thoracoabdominal asynchronism represented in phase angle φ and to evaluate the respiratory obstruction index $T_{me}/T_{E.}$. It has been shown that both parameters are sensitive predictors of certain pulmonary obstructive diseases (9, 10). Unlike other methods, the sedative treatment, required for the examination of children below the age of 5 years, is not necessary (11, 12).

The aim of this study was to analyze the influence of mother's smoking during pregnancy on the airway obstruction parameters (phase angle φ and T_{me}/T_E index) in small children using the method of respiratory inductive plethysmography.

MATERIAL AND METHODS

The study was approved by the Ethics Committee of the Jessenius Faculty of Medicine, Comenius University in Martin, Slovakia. Written informed consent was obtained from children's parents. A hundred and twenty seven healthy children up to the age of 24 months, 81 boys and 46 girls, were included into the trial. The average age of children was 11.2 ±0.6 (SE) months and weight 10.8 ±0.4 kg.

The following criteria were considered for inclusion: negative family and personal history regarding allergic diseases; physiological course of pregnancy and birth and postpartum adapting period; none inborn pulmonary or cardiovascular abnormalities; a minimum time difference between an acute inflammatory disease and the measurement of one month, and no medication that could influence the respiratory functions.

Children were divided into to age-groups: up to 6 moths and above 6 months of age. The first subgroup consisted of 7 healthy children of smoking mothers and 34 children of non-smoking mothers. The subgroup of older children was composed of 10 children of smoking mothers and 76 children of non-smoking mothers. All children were investigated in the supine position (13),

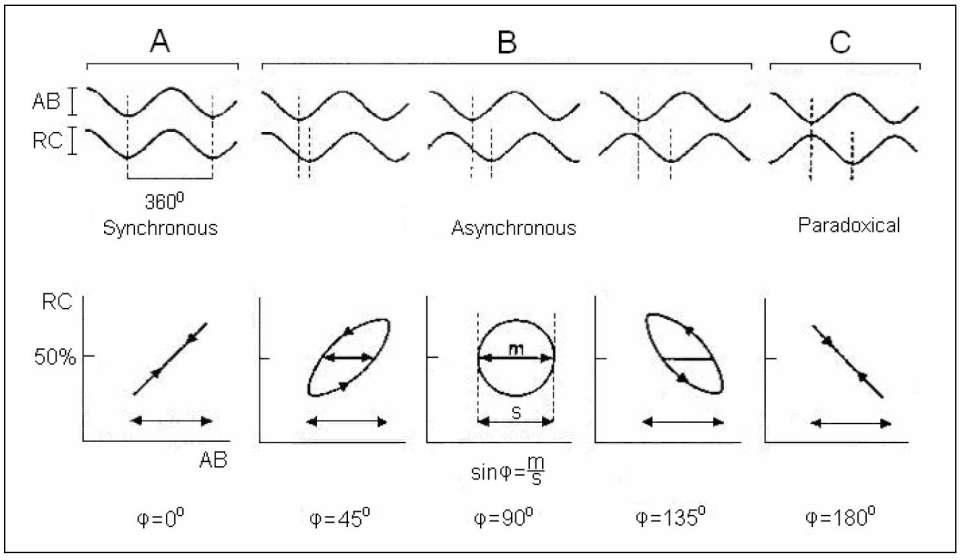

Fig. 1. Rib cage and abdominal curves presented as lissajous loops in x and y axis. The diagram also represents the type of respiratory pattern and the corresponding phase difference, the lissajous loop presentation, and the phase angle φ value.

without any sedatives applied. The minimum time interval from food intake to the beginning of investigation was 30 min. The elastic bands required by the measurement set-up were the only kind of confinement of the children.

A respitrace system (Studley Data Systems 150, England) for respiratory inductive plethysmography was used. The principle of the measurement is based on recording the time-dependent changes of the extent of movements during breathing by two elastic bands (14) – one placed around the trunk at the level of the nipples and the other placed at the level of the navel (Respibands Transducer, Ambulatory Monitoring, USA). Changes of thoracic and abdominal circumferences during breathing induce extension or contraction of both bands and in this manner convert the fiber's induction (15, 16). The intensity of induction was transferred to an analog-digital data converter (Lungenfunktionsmessgerät, Germany) for archiving on PC and later off-line analysis.

In this study we evaluated the thoracoabdominal asynchronism (TAA) assessed from the phase angle φ and T_{me}/T_E index. The phase angle φ was calculated from the phase difference between the rib cage and abdominal signals based on lissajous loop presentation described in x and y axis. Furthermore, the following mathematical functions for computation of phase angle φ were used: sin φ=m/s or φ=180°-u; u=m/s. The value labeled as „m" presents the distance of lissajous loop margins and „s" value represents the extent of lissajous loop in x axis (*Fig. 1*). Generally, the phase angle value is increased when airways obstruction occurs (17, 18). The T_{me}/T_E index was calculated from so called "airflow" curve construed from a total sum of abdominal and rib cage signals, representing "respiratory volume" (*Fig. 2*). The index represents the ratio between the time from the beginning to the maximum of expiratory airflow (T_{me}) and total expiratory time (T_E). The T_{me}/T_E index is decreased when airways obstruction occurs.

Minimum 5 consequently recorded breathing cycles, not influenced by movements, were required for the evaluation of both parameters. The values of phase angle φ and T_{me}/T_E index were

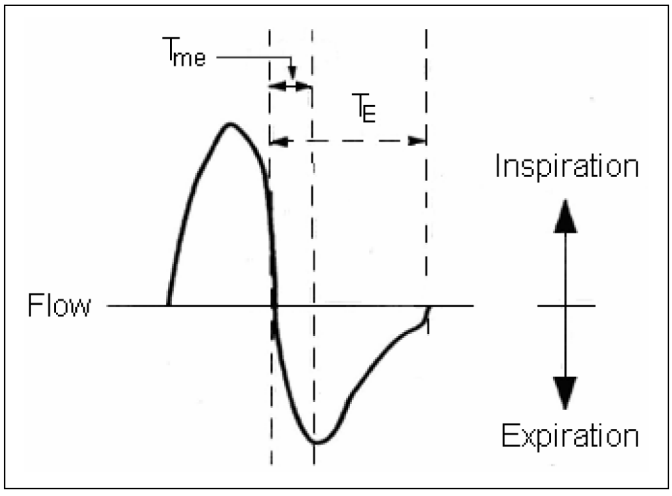

Fig. 2. The assessment and calculation of the T_{me}/T_E index.

calculated in each breathing cycle and then were averaged, and finally expressed as means ±SE. For statistical analysis we used a *t*-test for paired data. $P<0.05$ was considered to indicate significant differences.

RESULTS

We found a significant decline in phase angle φ values ($P<0.05$) in the healthy children of up to 6 months of age of non-smoking mothers compared with the children of smoking mothers in the same age-group (*Fig. 3*). This decrease did not appear in the evaluation of the same parameter in the children older than 6 months. Among children of smoking mothers, significantly lower phase angle φ values ($P<0.05$) were observed in the 6 months olds than in those above 6 months of age.

There was a significant increase ($P<0.05$) of T_{me}/T_E index in the non-smoking mothers' children (group 0-6 months of age). However, no appreciable changes in this index were present in the children older than 6 months (*Fig. 4*). The T_{me}/T_E indexes of the smoking mothers' children of up to 6 months of age were significantly augmented ($P<0.05$) in comparison with both subgroups of older children.

DISCUSSION

The present study assessed the influence of mother smoking during pregnancy on pulmonary function assessed as the phase angle φ and T_{me}/T_E index. Our study was based on the knowledge that the fetus is exposed in mother's womb to

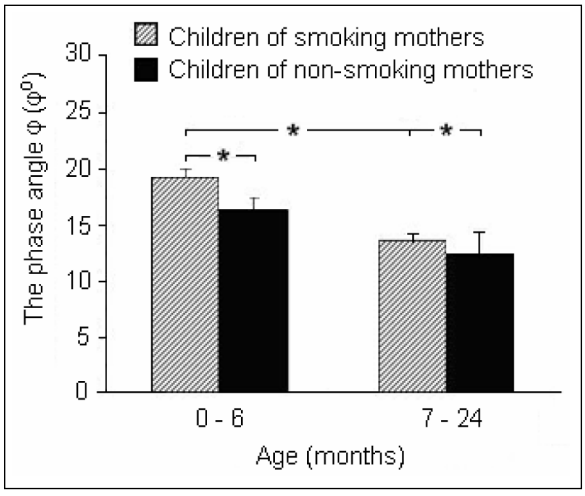

Fig. 3. Comparison of phase angle φ values between the groups of healthy children below and above the age of 6 months in relation to the mother's smoking or not during pregnancy.

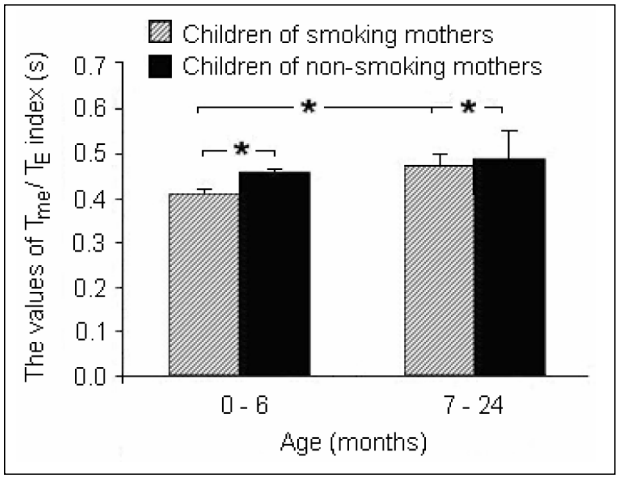

Fig. 4. Comparison of T_{me}/T_E index values between the groups of healthy children below and above the age of 6 months in relation to the mother's smoking or not during pregnancy.

vasoactive compounds, such as NO and nicotine, which might by triggering factors in the pathogenesis of symptomatic airway obstruction at the neonate and early childhood age.

A significantly lower value of phase angle φ ($P<0.05$) in healthy non-smoking mother's children compared with that in children of smoking mothers indicates that smoking has an impact on the respiratory system function. This impact was especially evident in young babies, up to the age of 6 months, with a diminishing tendency with increasing age. The phase angle φ values of children older than 6 months were close to those physiologically present in children of non-smoking mothers. Similar changes also concerned the T_{me}/T_E index. According to Elliot *et al* (4), the age-related differences could be due to internal thickness of airway

walls. The authors showed significant structural changes of the airways in children exposed to intrauterine passive smoking (mother smoked more than 20 cigarettes daily) that resulted in airway contraction and pulmonary functions abnormalities.

Our findings point to increased predisposition to respiratory disorders at a higher age of children whose mothers smoked in pregnancy. This result is supported by other studies (20-22). Zlotkowska *et al.* (23) drew attention to rapidly escalating incidence of airways obstruction with children's age. Piccioni *et al.* (24) reported that elevated occurrence of asthmatic symptoms and allergy in children correlated with smoking of mothers during pregnancy. That fact is confirmed by other authors who report elevated susceptibility to atopy in children whose mothers smoked during pregnancy (3, 5, 19).

We conclude that smoking of mothers in pregnancy represents a risk factor for respiratory disorders due to disturbed development of the respiratory system. Therefore, it is necessary to assume children of smoking mothers as pediatric risk patients in whom a long-term monitoring seems suitable.

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REFERENCES

1. Hasnis E, Bar-Shai M, Burbea Z, Reznick AZ. Cigarette smoke-induced NF-κB activation in human lymphocytes: the effect of low and high exposure to gas phase of cigarette smoke. *J Physiol Pharmacol* 2007; 58 Suppl 5: 263-274.
2. Hasnis E, Bar-Shai M, Burbea Z, Reznick AZ. Mechanisms underlying cigarette smoke-induced NF-κB activation in human lymphocytes: the role of reactive nitrogen species. *J Physiol Pharmacol* 2007; 58 Suppl 5: 275-287.
3. Soyseth V, Kongerud J, Boe J. Postnatal maternal smoking increases the prevalence of asthma but not bronchial hyperresponsiveness or atopy in their children. *Chest* 1995; 107: 389-394.
4. Elliot J, Vullermin P, Robinson P. Maternal cigarette smoking is associated with increased inner airway wall thickness in children who die from sudden infant death syndrome. *Am J Respir Crit Care Med* 1998; 158: 802-806.
5. Grzelewska-Rzymowska I, Kowejsza A, Kwiatkowska S. Atopy with recurrent wheezy bronchitis in children. *Pneumonol Allergol Pol* 2001; 69: 73-83.
6. Stocks J. Recent advances in the assessment of lung function in infants. *Pneumologie* 1991; 45: 881-886.
7. Lewis S, Richards D, Bynner J, Butler N, Britton J. Prospective study of risk factors for early and persistent wheezing in childhood. *Eur Respir J* 1995; 8: 349-356.
8. Strachan DP, Butland BK, Anderson HR. Incidence and prognosis of asthma and wheezing illness from early childhood to age 33 in a national British cohort. *BMJ* 1996; 312: 1195-1199.
9. Morris MJ, Madgwick RG, Collyer I, Denby F, Lane DJ. Analysis of expiratory tidal flow patterns as a diagnostic tool in airflow obstruction. *Eur Respir J* 1998; 12: 1113-1117.

10. Martinez FD. Role of respiratory infection in onset of asthma and chronic obstructive pulmonary disease. *Clin Exp Allergy* 1999; 29 Suppl 2: 53-58.
11. Clarenbach CF, Senn O, Brack T, Kohler M, Bloch KE. Monitoring of ventilation during exercise by a portable respiratory inductive plethysmograph. *Chest* 2005; 128: 1282-1290.
12. Sackner M. Labored breathing index. In Respievents (EDP), Non-invasive monitoring systems. M Sackner (ed). Miami Beach, USA, 1995, p. 4.
13. Levy J, Habib RH, Liptsen E, Singh R, Kahn D, Steele AM, Courtney SE. Prone versus supine positioning in the well preterm infant: effects on work of breathing and breathing patterns. *Pediatr Pulmonol* 2006; 41: 754-758
14. Moore CA, Caulfield TJ, Green JR. Relative kinematics of the rib cage and abdomen during speech and nonspeech behaviors of 15-month-old children. *J Speech Lang Hear Res* 2001; 44: 80-94.
15. Leino K, Nunes S, Valta P, Takala J. Validation of a new respiratory inductive plethysmograph. *Acta Anaesthesiol Scand* 2001; 45: 104-111.
16. Mikkilineni S, England S. On tidal expiratory flow measurements in infants. *Pediatr Pulmonol* 1994; 18: 71-72.
17. Allen JL, Wolfson MA, McDowell K, Shaffer TH. Thoracoabdominal asynchrony in infants with airflow obstruction. *Am Rev Respir Dis* 1990; 141: 337-342.
18. Sivan Y, Deakers TW, Newth CJL. Thoracoabdominal asynchrony in acute upper airways obstruction in small children. *Am Rev Respir Dis* 1990; 142: 540-544.
19. Magnusson CG. Maternal smoking influences cord serum IgE and IgE levels and increases the risk of subsequent infant allergy. *J Allergy Clin Immunol* 1986; 78: 898-904.
20. Tager IB, Ngo L, Hamrahan JP. Maternal smoking during pregnancy. Effects on lung function during the first 18 months of life. *Am J Respir Crit Care Med* 1995; 152: 977-983.
21. Strachan PD, Cook DG. Parental smoking and lower respiratory illness in infancy and early childhood. *Thorax* 1997; 52: 905-914.
22. Young S, Sherril DL, Arnott J, Diepeveen D, LeSouef PN, Landau LI. Parental factors affecting respiratory function during the first year of life. *Pediatr Pulmonol* 2000; 29: 331-340.
23. Zlotkowska R, Zejda JE, Jazwiec-Kanyion B. Fetal exposure to environmental tobacco (ETS) and respiratory health status in Polish younger schoolchildren. *Eur Respir J* 2001; 33: 372.
24. Piccioni P, Migliore E, Ciccone G, Carosso A, Bugiani M. Respiratory symptoms and risk factors in school-age population. *Eur Respir J* 2001; 33: 372.

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Author's address: Slavomir Nosal, Department of Paediatrics, Comenius University in Bratislava, Jessenius Faculty of Medicine, Kollarova 2 St., 036 59 Martin, Slovakia; phone: +421 043 4203192, fax: +421 043 4222678; e-mail: slavonosal@yahoo.com