·论著(译文)·

Lung Function Test via Tidal Breathing in Infants before and after the Treatment of Pneumonia

ZHANG Hao, SUN Bo, REN Ci-Fang, CAI Ying-Yun

Department of Pediactrics, Children's Hospital, Fudan University, Shanghai 200032, *China*

Abstract: **Objective** To study the lung function changes of infants with pneumonia via tidal breathing pattern analysis before and after treatment. **Methods** Tidal Flow-Volume Loops (TFV) were measured using the tidal breathing pattern in 58 infants (1～40 months old) with pneumonia. Sixty-three normal infants were used as controls. The parameters, including respiratory rate (RR), inspiratory and expiratory time (Ti, Te), the ratio of Ti/Te, peak tidal expiratory flow (PTEF), the ratio of time to reach peak tidal expiratory flow (TPTEF) to total expiratory time (TE), the ratio of volume to reach peak tidal expiratory flow (VPEF) to total expiratory volume (VE), tidal volume per kilogram (VT/kg), mean inspiratory flow (MIF), mean expiratory flow (MEF), and tidal expiratory flow at 25 %, 50 %, 75 % lung volume (TEF 25 %, TEF 50 % and TEF 75 %) were measured using the Masterscreen-Paediatric (a tool for the lung function test). **Results** RR increased, TPTEF, TPTEF/TE, VPEF, VPEF/VE were lower in infants with pneumonia compared with those of the controls [RR = (36 ± 9)/min vs (30 ± 8)/min, TPTEF = (0.20 ± 0.08) s vs (0.40 ± 0.16) s, TPTEF/TE = (18.8 ± 5.8) % vs (33.0 ± 7.5) %, VPEF = (17.2 ± 10.9) ml vs (25.4 ± 12.8) ml, VPEF/VE = (22.1 ± 4.6) % vs (33.4 ± 6.35) %] ($P < 0.01$). TI, TE, TI/TE were shortened. It appeared that the airway was obstructive. After the routine therapy, RR decreased to (33 ± 11)/min, TPTEF/TE and VPEF/TE were significantly higher [(26.2 ± 8.7) and (8.4 ± 7.3) %, respectively] ($P < 0.01$). **Conclusions** Tidal breathing pattern can be used to evaluate the lung function and the effect of therapy in infants with pneumonia.

Key words: Tidal breathing; Lung function; Pneumonia; Infant

[CLC number] R725.6 **[Document code]** A **[Article ID]** 1008 - 8830(2001)04 - 0478 - 04

It has been demonstrated that respiratory disorder is the main disease in children. It represents the most common cause of death in infants worldwide. The patients, especially the younger children and infants with their developing respiratory systems, represent a challenge for the clinician. The ability to measure pulmonary function provides a tool that can confirm a clinical diagnosis, monitor the response to therapy, and follow the progression of disease[1].

The traditional forced expiratory technique measures the flow and volume requiring patients to take a slow deep breath to total lung capacity, and then exhale as quickly and completely as possible. Obviously this is not appropriate for infants. The tidal breathing method only needs quiet respiration, so it is very simple and suits infants. This report describes measurment of lung function using the tidal breathing technique in 58 patients before and after the treatment.

1 Materials and Methods

The study group consisted of 58 infants (40 males) at a mean age of 15 (ranging 1-40 months old). All were hospitalized because of coughing (some with fever, and tachypnea), fine rales and exudation in X-ray.

The control group consists of 63 infants (38 males) at a mean age of 15.8 (ranging 1-40 month old). No respiratory infection within 2 weeks, passive smoking, asthma heredity, and congenital dis-

[Received] October 25, 2000; [Revised] Februrary 15, 2001
[Introduction to the First Author] ZHANG Hao (1966 -), Female, Bechelor, Attending Physician.

ease were detected which would affect the respiratory function.

The pulmonary function tool used was the Masterscreen-Paediatric, developed by the Jaeger company, Germany. The volume and flow, and its time integral were calibrated before each patient using a precision syringe every morning. Measurements in the infants were frequently obtained following sedation with 20-30 mg/kg chloral hydrate given orally[2]. The infants were studied in the supine position. When the infant was in quiet sleep, a thin ring of therapeutic silicone was placed around nose and mouth. Airflow was measured using a pneumotachograph (attached to a mouthpiece) and a flow transducer and was subsequently integrated to the tidal volume. The data were recorded 5 times, each time consisting at least 20 breaths[3]. On conclusion of the measurement, the computer processed the data and provided the average values. All the tests were performed at 8-10 AM.

Up to 30 parameters were identified for each breath, including respiratory rate (RR), inspiratory and expiratory time (Ti, Te), inspiratory time as a ratio to expiratory time, peak tidal expiratory flow (PTEF), time to reach peak tidal expiratory flow as a ratio of total expiratory time (TPTEF/TE), volume to reach peak tidal expiratory flow as a ratio of total expiratory volume (VPEF/VE), tidal volume per kilogram (VT/kg), mean inspiratory flow (MIF), mean expiratory flow (MEF), and tidal expiratory flow at 25%, 50%, 75% lung volume (TEF25%, TEF50%, TEF75%). Results are displayed as the mean and standard deviation (SD) for each parameter over the specified number of breaths. A P value of less than 0.05 was considered to be statistically significant.

Also we got a tidal flow-volume (TFV) loop, the lower part representing inspiration, and the upper part represents expiration.

2 Results

There was no significant difference between the groups with respect to sex, age, weight, and length at the time of test. Characteristics of the two groups and the results of tidal breathing analyses are summarized in Table 1. When hospitalized, patients with pneumonia showed high RR, lowed Ti, Te, especially Ti, and increased MIF, MEF, PEF. But the increasing range from TEF75%, TEF50% to TEF25% became small. Even TEF25% showed no significant change. TPTEF, VPEF, TPTEF/TE, and VPEF/VE all decreased obviously. Figure 1 is the TFV loop of a 33-month-old healthy boy. Figure 2 is a 13-month-old boy with pneumonia; the slope of TFV loop was steep. Figure 3 is the same patient after therapy; we can see the slope became flattened.

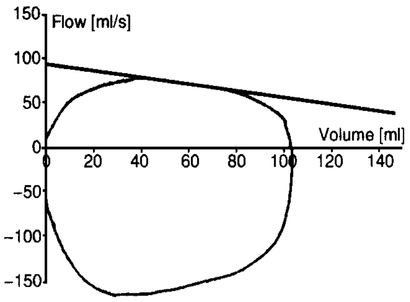

Figure 1 TFV loop the same of a healthy baby

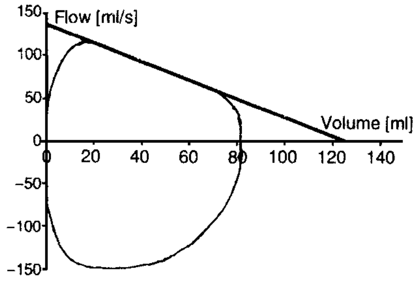

Figure 2 TFV loop of a patient with pneumonia before therapy

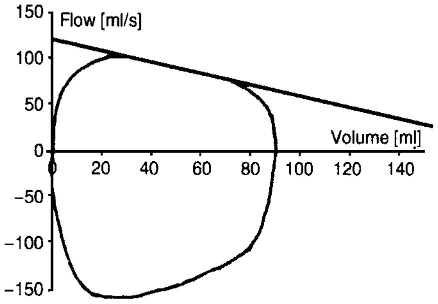

Figure 3 TFV loop of patient after the same patient after therapy

After therapy, compared with the time when hospitalized, RR decreased, Ti, Te increased and TPTEF, VPEF, TPTEF/TE, VPEF/VE were higher, but they still could not match those of the healthy children (Table 1).

Table 1 Main parameters of tidal breathing in healthy baby and in infants before and after treatment of pneumonia ($\bar{x} \pm S$)

Parameters	Healthy Infants(Ⅲ)	Before Treatment(Ⅰ)	After Treatment(Ⅱ)
VT(ml/kg)	7.39 ±1.43	7.48 ±2.41	8.22 ±2.68^{b,d}
RR(times/min)	29.8 ±8.1	35.7 ±9.3^{a}	32.7 ±10.8^{a,c}
TI(s)	0.96 ±0.28	0.74 ±0.17^{a}	0.81 ±0.19^{a,c}
TE(s)	1.20 ±0.34	1.04 ±0.28^{a}	1.19 ±0.36^{a,c}
TI/TE	0.80 ±0.14	0.73 ±0.13^{a}	0.71 ±0.12^{a}
TPTEF(s)	0.40 ±0.16	0.20 ±0.08^{a}	0.31 ±0.16^{a,c}
TPTEF/TE(%)	33.0 ±7.54	18.8 ±5.77^{a}	26.2 ±8.70^{a,c}
VPEF(ml)	25.4 ±12.8	17.2 ±10.9^{a}	25.5 ±10.5^{a,c}
VPEF/VE(%)	33.4 ±6.35	22.1 ±4.62^{a}	28.4 ±7.30^{a,c}
PEF(ml/s)	74.2 ±29.3	109 ±57.5^{a}	104 ±82.1^{a}
TEF75%(ml/s)	69.4 ±28.4	107 ±57.4^{a}	100 ±79.0^{a}
TEF50%(ml/s)	69.4 ±28.1	86.6 ±52.0^{a}	92.2 ±81.1^{a,d}
TEF25%(ml/s)	54.9 ±25.1	58.5 ±42.2^{a}	68.7 ±69.8
TEF 25/PEF(%)	0.72 ±0.12	0.52 ±0.16^{a}	0.62 ±0.14^{a,c}
MIF(ml/s)	78.9 ±30.0	104 ±66.9^{b}	105 ±76.5^{a}
MEF(ml/s)	60.6 ±18.7	73.3 ±44.0^{a}	75.0 ±56.1^{b}

a ($P < 0.01$) and b ($P < 0.05$) represented statistical differences compared with the controls; c ($P < 0.01$) and d ($P < 0.05$) represented statistical differences compared with the children before treatment ($P < 0.05$)

3 Discussion

Tidal breathing test acts as a kind of pulmonary function test which requires no patient co-operation and its simplicity suggests that it can be the best fit to little babies. In our study, the children, when sedated, could respire quietly through a facemask[5], without discomfort and influence by subjective factors. The veracity and repeatability of the test were thus ensured.

Before the therapy, the patients experienced higher RR, MIF, MEF, PEF, and lower Ti, Te, Ti/Te (Te was relatively high), suggesting that with pneumonia the respiratory center was obviously excited in order to inpel the patient for respiration more quickly, so as to increase the minute ventilation to satisfy the increasing O2 need. But we have also found at the same time that the increasing range from TEF75%, TEF50% to TEF25% became smaller, and TEF25% even had no significant change. This elaborates that when infected small airways are obviously edema and obstructive. Even if the driving force increases, it cannot make the flow in small airways higher. This suggests that the main pathological change is in the small airways.

In the TFV loop, the X-axis is volume, and the Y-axis represents flow. VT decides the width of the loop, and resistance influences the shape and makes the slope change. The more severe the obstruction, the steeper the slope will be and it will even show the sinking of the falling line of expiration. With the TFV loop of the healthy baby as standards (oval), pneumonia patients before therapy revealed high PEF, and the elevated range of TEF75%, TEF50% to TEF25% became smaller and smaller. TEF25% even had no significant change. The more severe pneumonia is, the more severe the obstruction, and more obvious for this trend. Then the falling line of expiratory will be sunken.

In the tidal breathing, considering TPTEF/TE, VPEF/VE as the index of airway obstruction has been affirmed by many specialties[4,6,7]. Some people have studied healthy children of different ages, and some have studied asthma children before and after inhaling bronchial dilator. They all find that these two parameters have significant meanings, especially TPTEF/ TE. In patients with asthma or lower airway obstruction, their values are low. In our study, we compared them before and after therapy in young children with pneumonia. The result was that before therapy, TPTEF/ TE, VPEF/ VE were lower; after therapy, they became higher. But they are not as high as the normals. This illustrates that, even if it seems recovered and has no clinical symptoms, the infection and damage of airways need more recovery. As for when the lung function will completely recover, we need to follow up.

References

[1] John K, Pfaff MD, Wayne J, et al. Pulmonary function in infants and children [J]. Respiratory Medicine. Pediatr Clin North Am, 1994, 41: 401 - 423.

[2] American Thoracic Society / European Respiratory Society, Respiratory function measurements in infants: measurement conditions [J]. Am J Repir Crit Care Med, 1995, 151: 2058 - 2064.

[3] Windstetter D, Foitzik B, Schmalisch G, et al. Long term tidal breathing measurements in newborns: influence of a bias flow on ventilatory parameters [J]. Eur J Med Res, 1999 Jan 26, 4 (1): 15 - 22.

[4] Wu JC, Fan XM, Liu XC, et al. The characteristics and significance of tidal flow-volumeloopin healthy babie. J Appl Clin Pediatr, 1999, 14 (1): 11 - 12.

[5] Morris MJ, Madgwick RG, Collyer I, et al. Analysis of expiratory tidal flow patterns as a diagnostic tool in airflow obstruction [J]. Eur Respir J, 1998 Nov, 12 (5): 1113 - 7.

[6] Cornelis K, Van der Ent, Henricus J L, et al. Tidal breathing analysis as a meassure of airway obstruction in children three years of age and older [J]. Am J Respir Crit Care Med, 1996, 153: 1253.

[7] Shao J, Zhao JQ, Gao R, et al. The application and analysis of tidal breathing parameters in asthmatic children with accute airway obstruction [J]. Chin J Pediatr, 1999, 37 (12): 724 - 726.

(本文编辑:孙晓玲)