Defining and describing airways obstruction in children

K.F. Kerrebijn*

The two most common diseases with airway obstruction from pre-school age are asthma and cystic fibrosis (CF). Airway diseases in infancy will not be discussed. For reasons of simplicity, asthma is defined as the complex coexistance of one or more of the symptoms wheeze, breathlessness, cough, mucus hypersecretion, which are either chronically or intermittently present and which are generally triggered by viral infections, allergens, pollutants (cigarette smoke), exercise, sudden changes in temperature of the inspired air *etc*.

Criteria for airway obstruction

Diminishment of airway calibre

In most patients with asthma and CF, airway calibre is diminished. This may however be within the normal range. Criteria for diminishment are an absolute value of the index taken which is 1) lower than -2 standard deviations from predicted or 2) lower than -1.65 standard scores (SS) (measured minus predicted value/within subject coefficient of variation), which indicates the lower limit of the 95% confidence interval. The use of SS has the advantage that the variability of the measurement is taken into account.

Theoretically, the shape of the flow-volume curve can be used to diagnose airway obstruction. An attempt has been made to relate the size and shape of flow-volume curves, obtained in an epidemiological follow up study of healthy adult subjects, to respiratory symptoms. Although different patterns could be distinguished, application of the shape of the flow-volume curve for the quantification of airway obstruction in patients is not yet possible [1, 2].

Change of airway calibre after bronchodilatation

In patients with asthma there is generally a significant increase in airway calibre after the administration of a bronchodilator, also if the baseline value is within the normal range. Most patients with cystic fibrosis show a limited, statistically not significant increase in airway calibre after bronchodilatation, which is comparable to the effect of a bronchodilator in healthy subjects [3, 4]. Bronchodilator responsiveness may however improve transiently during hospital admission together with improvement in baseline value [3].

Whether a change in airway calibre after bronchodilatation is significant depends on the expression of the results. This can be done in absolute values (not applicable in children because of differences in size), % of baseline, % of predicted and % achievable (predicted minus baseline). Results which are expressed in % of baseline and % achievable are dependent on the initial value in contrast to results expressed in % of predicted (table 1).

Table 1. – Predicted 2500 ml; increase after bronchodilatation 250 ml.

	Increase after bronchodilatation		
	% baseline	% predicted	% achievable
1000–1250	25	10	16.6
1500–1750	16.6	10	25
2000–2250	12.5	10	50

Reference values for bronchodilator responses in healthy children and adolescents, expressed in % of baseline are given by CASAN *et al* [4] and in asymptomatic, never smoking subjects aged 7–75 years in % of predicted by DALES *et al* [5].

Tests for measuring airway calibre in children

From about 3 years of age, pulmonary resistance (Rrs), functional residual capacity (FRC) and the change in transcutaneous oxygen tension (Δ $Ptco_2$) can be used.

Rrs can be measured by forced oscillometry (FOT). We use the forced pseudo-random noise technique according to Landser by which the Rrs and the reactance of the respiratory system can be measured simultaneously at various frequencies [6]. Values of both the mean Rrs over a frequency spectrum of 2–26 Hz (Rrs) and the Rrs at 6 Hz (Rrs_6) correlate significantly with airway resistance measured by whole body plethysmography [7].

FRC using the Helium gas dilution technique can be measured easily in children from 3 years, using a 4.5 *l* spirometer bell [8]. The results compare nicely with the FEV_1, which makes this method a feasible one to assess the effect of bronchodilatating agents in young children.

$Ptco_2$ is a sensitive measure of induced bronchoconstriction. We recently completed a study in which we measured the dose-response curves to inhaled methacholine concurrently with $Ptco_2$ and FEV_1. We found in 54 children with asthma aged 6–14 yrs that $Ptco_2$, PD_2O and PD_2O FEV_1 correlated highly [9]. In children from about 5 years of age, peak flow measurements (PF), spirometry and flow-volume curves can be used to measure airway calibre at baseline and after bronchodilatation or induced bronchoconstriction. From the age of about 8 whole body plethysmography becomes a feasible technique.

Dept of Paediatrics, Division of Pediatric Pulmonary Medicine, University Hospital Rotterdam/Sophia Children's Hospital and Erasmus University Rotterdam, The Netherlands.

Table 2. – Indices of airway calibre in children

	Within-subject variability	To be used for the quantification of		
		baseline airway calibre	broncho-constriction	broncho-dilatation
FOT	± 12%	+	+	+
FRC	< 10%	-	-	+
$\Delta Ptco_2$	< 2 mm	-	+	-
PF	± 5%	+	+	+
FEV_1	< 5%	+	+	+
Flow-volume indices	± 12%	+	+	+
sGaw	± 10%	+	+	+

Induced bronchoconstriction can be obtained with histamine, methacholine and cold air from a young age (about 3) and with exercise from the age of about 5. PF measurements can be used, together with symptoms, for daily recordings at home.

The diurnal variability of PF, *i.e.* the difference between the lowest morning or evening value after an inhaled beta-2-agonist, correlates highly with the airway responsiveness to histamine or methacholine in adults [10]. No data exist on children.

Table 2 summarizes the indices which can be used in childhood to measure airway dilatation or obstruction. Reference values have recently been published [11].

References

1. Van Pelt W, Quanjer PhH, Borsboom GJJM, van der Lende R. – Respiratory symptoms and the maximum expiratory flow-volume curve; a multivariate approach. *Eur Respir J*, 1988, 1, 122–132.
2. Van Pelt W, Quanjer PhH, van der Lende R. – Longitudinal change and diagnosticity of multivariately derived variables from flow-volume curves. *In*: Van Pelt W, Thesis, Leiden, 1988.
3. Hordvik NL, König P, Morris D, Krentz C, Barbero GJ. – A longitudinal study of bronchodilator responsiveness in cystic fibrosis. *Am Rev Respir Dis*, 1985, 131, 889–893.
4. Casan P, Roca J, Sanchis J. - Spirometric response to a bronchodilator. Reference values for healthy children and adolescents. *Bull Europ Physiopath Respir*, 1983, 19, 567–569.
5. Dales RE, Spitzer WO, Tousignant P, Schechter M, Suissa S. – Clinical interpretation of airway response to a bronchodilator. *Am Rev Respir Dis*, 1988, 138, 317–320.
6. Duiverman EJ, Neijens HJ, van der Snee-van Smaalen M, Kerrebijn KF. – Comparison of forced oscillometry and forced expirations for measuring dose-related responses to inhaled methacholine in asthmatic children. *Bull Eur Physiopathol Respir* ,1986, 22, 433–436.
7. Duiverman EJ. – Lung function and bronchial responsiveness in preschool children. Thesis, Rotterdam, 1985, p. 32.
8. Greenough A, Stocks J, Notlen U, Helms P. – Total respiratory compliance and functional residual capacity in young children. *Ped Pulmonol* ,1986, 2, 321–326.
9. Van Broekhoven P, Hop WCJ, Rasser E, Kerrebijn KF. – Comparison of FEV_1 and transcutaneous oxygen tension in the measurement of airway responsiveness to methacholine. Submitted for publication.
10. Ryan G, Latimer KM, Dolovich J, Hargreave FE. – Bronchial responsiveness to histamine: relation to diurnal variation of peak flow rate, improvement after bronchodilator and airway calibre. *Thorax*, 1982, 37, 423–429.
11. Quanjer PhH, Bjure J, Helms P, Gaultier CL. – Standardization of lung function tests in paediatrics. *Eur Respir J*, 1982, 2, suppl. 4.

The assessment of reversibility: What physiological tests?

M. Demedts*

The assessment of reversibility may be performed for different purposes *e.g.* for population studies or for the evaluation of the individual patient; and it may have different applications *i.e.* diagnostic, prognostic or therapeutic. These differences may determine to some extent the choice of physiological tests and the type of analysis of the measurements.

Dept of Pathophysiology, Laboratory for Pneumology, Catholic University Leuven,University Hospital,Weligerveld 1, B-3041 Pellenberg, Belgium.

Physiological tests

The most often applied tests and variables are those obtained during a forced expiratory manoeuvre after a full inspiration: *i.e.* FEV_1, FVC, PEF, MEFs and