Les EFR dans les maladies de l'enfant

(surtout dans l'asthme…)

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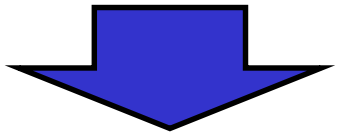
Les pathologies respiratoires de l'enfant

- **L'asthme avant tout**. Pathologie chronique la plus fréquente de l'enfant: environ 10% des enfants 90% de la consultation du Pneumopédiatre

- **Mucoviscidose**: maladie génétique létale à transmission autosomique récessive la plus fréquente dans les populations de type europoïde (1/4500 naissances ~200 enfants / an, 6500 sujets environ en France)



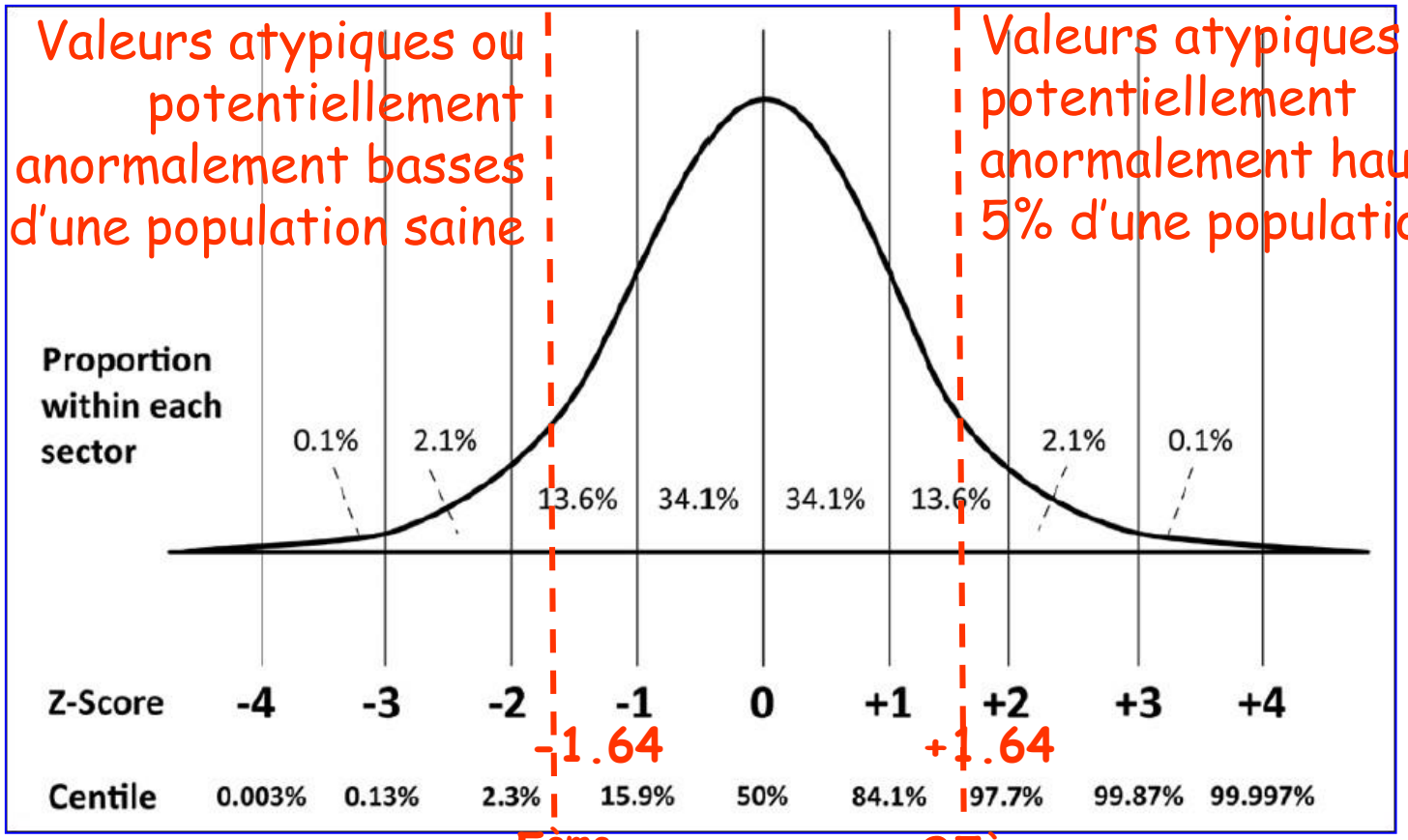
La problématique des EFR pédiatriques:
diagnostic de l'obstruction bronchique
Critère précis (z-score) et norme adaptée

LIN (LLN): limite inférieure de la normale
LSN (ULN): limite supérieure de la normale

Z-score: quantification écart versus normalité

$$z = \frac{x - \mu}{\sigma}$$

μ = Mean
σ = Standard Deviation



LIN = -1.64 RSD **LSN** = +1.64 RSD

Normes spirométriques: GLI 2012

Multi-ethnic reference values for spirometry for the 3–95-yr age range: the global lung function 2012 equations

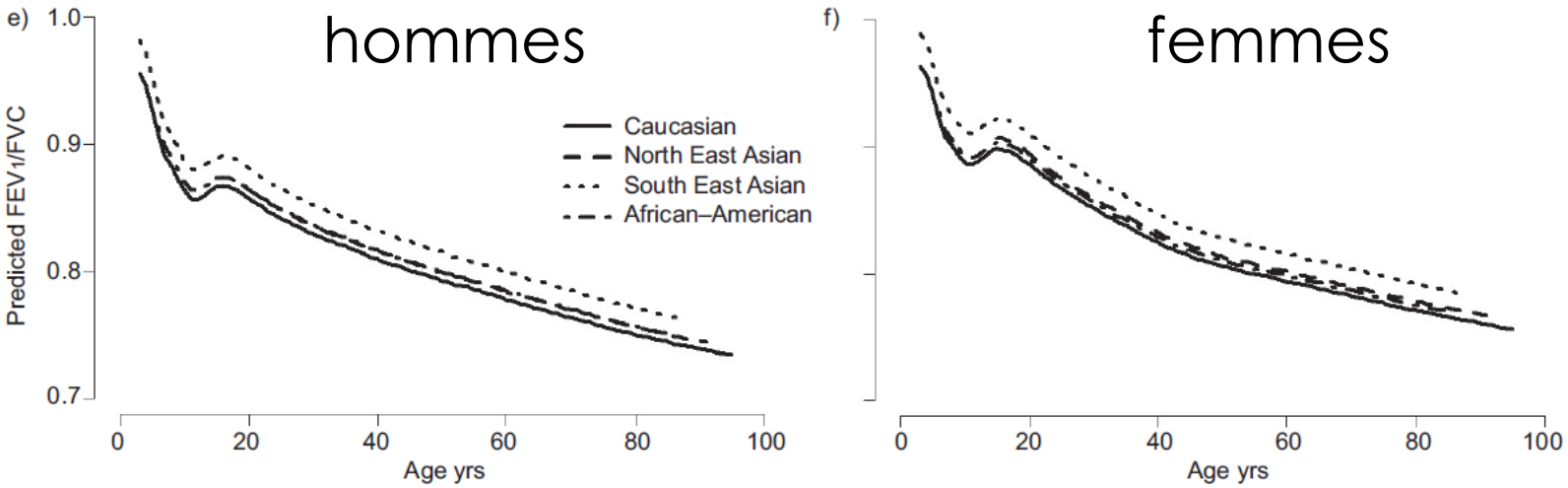
Eur Respir J 2012; 40: 1324–1343

Philip H. Quanjer, Sanja Stanojevic, Tim J. Cole, Xaver Baur, Graham L. Hall, Bruce H. Culver, Paul L. Enright, John L. Hankinson, Mary S.M. Ip, Jinping Zheng, Janet Stocks and the ERS Global Lung Function Initiative

reference equations were derived for healthy individuals aged 3–95 yrs for Caucasians (n=57,395), African–Americans (n=3,545), and North (n=4,992) and South East Asians (n=8,255).

Méthode statistique: LMS

Rapport VEMS/CVF



Interpretative Consequences of Adopting the Global Lungs 2012 Reference Equations for Spirometry for Children and Adolescents

Pediatric Pulmonology 49:118–125 (2014)

Philip H. Quanjer, MD, PhD,[1]* and Daniel J. Weiner, MD[2]

Adolescence: seule période de la vie avec ↗ rapport VEMS/CVF

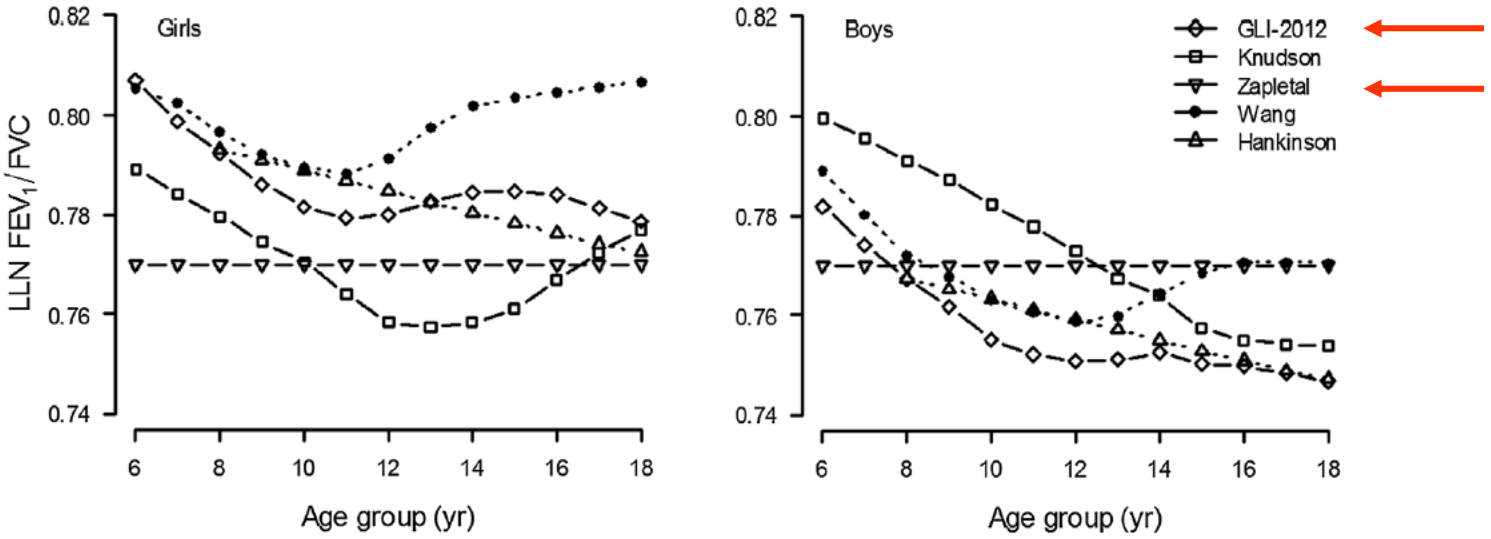


Fig. 1. The average lower limit of normal (LLN) for FEV_1/FVC by age group according to various prediction equations for white–American (top panels) and African–American (bottom panels) girls and boys. Age is centered, for example, 12 represents 11.5–12.49 year.

Zapletal pour garçons et filles (droite):

Équation FEV1/FVC = 90.6043 – 0.04104 x taille (RSD: 4.54)

AMERICAN JOURNAL OF RESPIRATORY AND CRITICAL CARE MEDICINE VOL 188 2013

Applicability of the Global Lung Function Spirometry Equations in Contemporary Multiethnic Children

Rachel Bonner, B.Sc.
Sooky Lum, Ph.D.
Janet Stocks, Ph.D.
Jane Kirkby, Ph.D.
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1291 enfants de 5-11 ans
asymptomatiques
14 écoles de Londres

Normes GLI:
Z-score pour chaque ethnie ~ 0

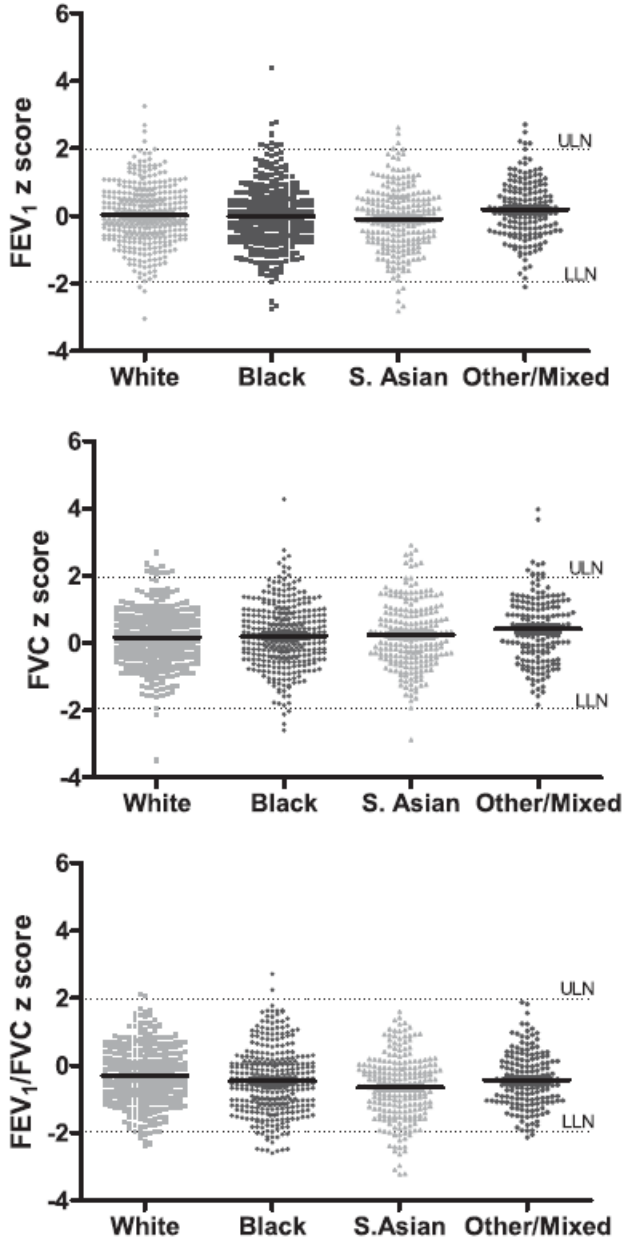


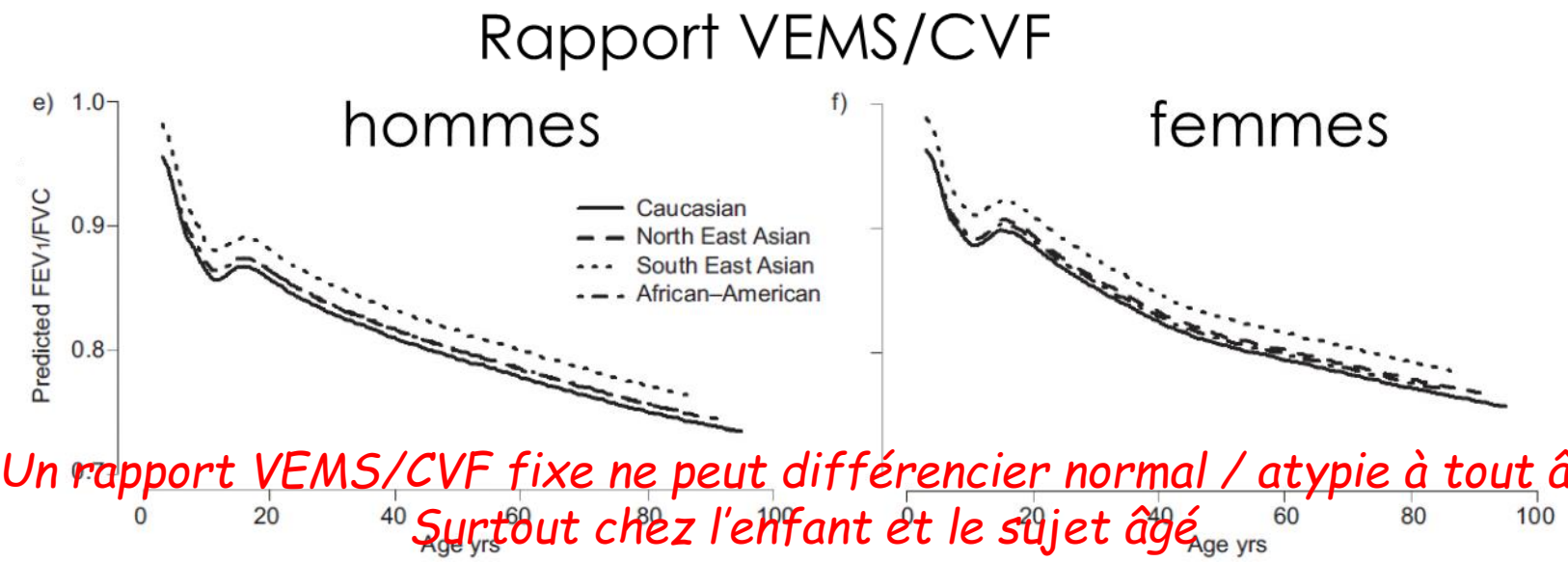
Figure 1. Spirometric lung function results according to the GLI-2012 ethnic specific reference equations (6). Data from South Asian children were expressed according the "South East Asian equation." For the purposes of this analysis the 95% limits of normality are shown.

Spirométrie: interprétation

- Recommandations ATS-ERS 2005
- Compte-rendu d'EFR (ATS 2017)

Diagnostic de l'obstruction bronchique

- Définition « simple » ? (rapport VEMS/CV fixe)
- Définition statistique ?



Un rapport VEMS/CVF fixe ne peut différencier normal / atypie à tout âge

Surtout chez l'enfant et le sujet âgé

GOLD-2007

VEMS/CV forcée < 0.70 (70%)

BPCO

Figure 2. Spirometric Classification of COPD Severity Based on Post-Bronchodilator FEV_1	
Stage I: Mild	$FEV_1/FVC < 0.70$

› Rev Mal Respir. 2010 Nov;27(9):1003-7. doi: 10.1016/j.rmr.2010.09.007. Epub 2010 Oct 8.

[Open letter to the members of the GOLD committee]

[Article in French]

Le groupe Pulmonaria, Philip H Quanjer, Paul L Enright, Janet Stocks, Gregg Ruppel, Maureen P Swanney, Robert O Crapo, Ole F Pedersen, Emanuela Falaschetti, Jan P Schouten, Robert L Jensen, ANZSRS : Australian and New Zealand Society of Respiratory; ARTP : Association for Respiratory Technology and Physiology; CAHAG : COPD and Astma Huisartsen Advies Groep (COPD and Asthma GP Advisory Group); SKL : Dutch Paediatric Repiratory Society; Education for Health, Warwick, UK; National Respiratory Training Center, Virginia, US; NHG : Nederlands Huisartsen Genootschap (Dutch Society of GPs); NVALT : Nederlandse Vereniging van Artsen voor Longziekten en Tuberculose (Dutch Thoracic Society); NVLA : Nederlandse Vereniging Longfunctie Analisten (Dutch Society of Respiratory Technicians); PCRS-UK : Primary Care Respiratory Society UK; Société de Physiologie; SPLF : Société de pneumologie de langue franc¸aise; SSMG : Société scientifique de médecine générale; WONCA: World Organization of Family Doctors

Spirométrie chez l'enfant

Effort expiratoire:
expiration forcée, maximale, reproductible
à partir de 3 ans
en pratique, plutôt à partir de 6 ans

Critères d'acceptabilité de chaque courbe
Au moins de 3 courbes reproductibles:
VEMS, CVF: différence de moins de 100 mL (petit)
Compte-rendu: préciser la reproductibilité (ou non)
selon les recommandations (grades)

Trouble ventilatoire obstructif: définition

TABLE 5 Types of ventilatory defects and their diagnoses

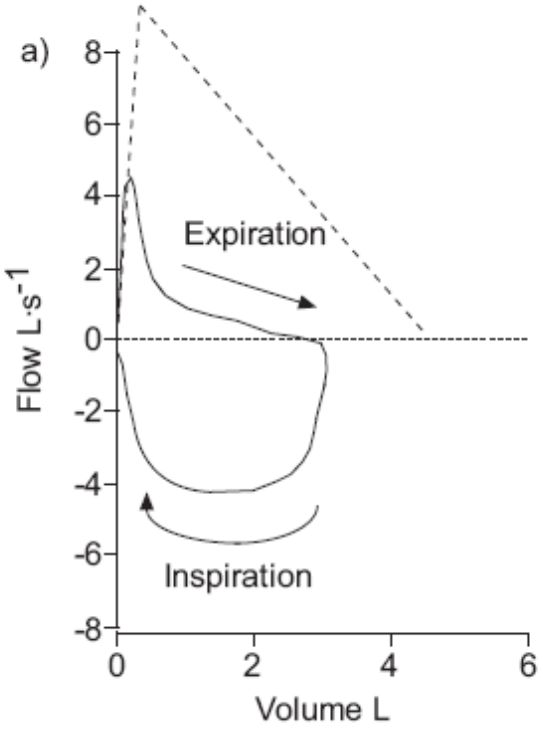
Abnormality	Diagnosis
Obstruction	FEV1/VC <5th percentile of predicted

VEMS/CV < 5eme percentile de la valeur prédite
Z-score de VEMS/CV < -1,64

Courbe volume-débit

Obstructive abnormalities

An obstructive ventilatory defect is a disproportionate reduction of maximal airflow from the lung in relation to the maximal volume (*i.e.* VC) that can be displaced from the lung [45–47]. It implies airway narrowing during exhalation and is defined by a reduced FEV1/VC ratio below the 5th percentile of the predicted value. A typical example is shown in figure 1a.



Gradation de la sévérité des troubles

TABLE 6 Severity of any spirometric abnormality based on the forced expiratory volume in one second (FEV_1)

Degree of severity	FEV_1 % pred
Mild	>70
Moderate	60–69
Moderately severe	50–59
Severe	35–49
Very severe	<35

% pred: % predicted.

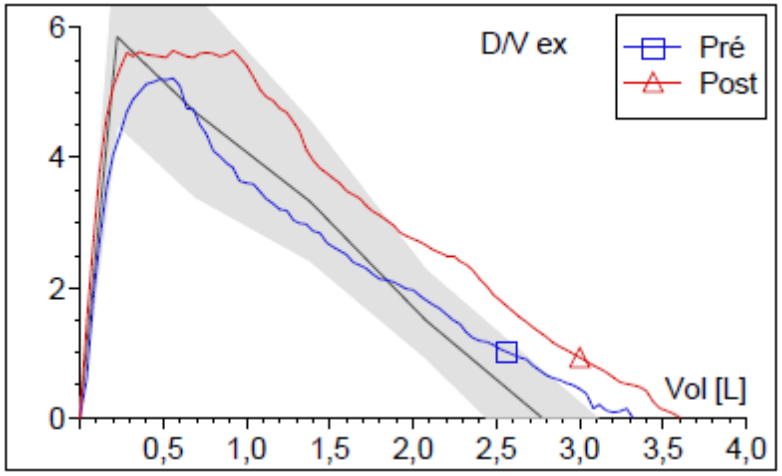
Indication: suivi de maladie asthmatique

Age:	**11 Années**	**Sexe:**	**masculin**
Taille:	**150 cm**	**IMC:**	**19**

Spirométrie +- bronchodilatateur (salbutamol 400 µg: postBD)
Norme (depuis début avril 2016) : GLI2012, adaptée à l'ethnie

		Mes. base	LIN	Z score	% Théo
TEF	**sec**	6.05			
VEMS	**L**	2.56	2.08	0.99	108
CVF	**L**	3.29	2.44	2.56	119
VEMS%CV	**%**	77.80	77.95	-1.67	90
DEMM	**L/s**	2.20	1.93	-1.08	80

Interprétation ?



Spirométrie +- bronchodilatateur (salbutamol 400 µg: postBD)
Norme (depuis début avril 2016) : GLI2012, adaptée à l'ethnie

		Mes. base	LIN	Z score	% Théo	Mes. post BD	Z score	% Théo	Réponse BD%
TEF	sec	6.05				5.22			-14
VEMS	L	2.56	2.08	0.99	108	2.97	3.30	125	16
CVF	L	3.29	2.44	2.56	119	3.58	4.01	129	9
VEMS%CV	%	77.80	77.95	-1.67	90	83.06	-0.68	96	7
DEMM	L/s	2.20	1.93	-1.08	80	2.96	0.41	108	35

TVO léger significativement réversible
(LIN de cet enfant: ~0,78 …)

Diagnostic d'asthme certain versus asthme probable

Réponse bronchodilatatrice

TABLE 9 Summary of the procedures relating to bronchodilator response

Procedures suggested to minimise differences within and between laboratories

- Assess lung function at baseline
- Administer salbutamol in four separate doses of 100 μg through a spacer
- Re-assess lung function after 15 min. If you want to assess the potential benefits of a different bronchodilator, use the same dose and the same route as used in clinical practice. The wait time may be increased for some bronchodilators

An increase in FEV_1 and/or FVC ⩾12% of control constitutes a positive bronchodilator response

In the absence of a significant increase in FEV_1 and/or FVC, an improvement in lung function parameters within the tidal breathing range, such as increased partial flows and decrease of lung hyperinflation, may explain a decrease in dyspnoea

The lack of a bronchodilator response in the laboratory does not preclude a clinical response to bronchodilator therapy

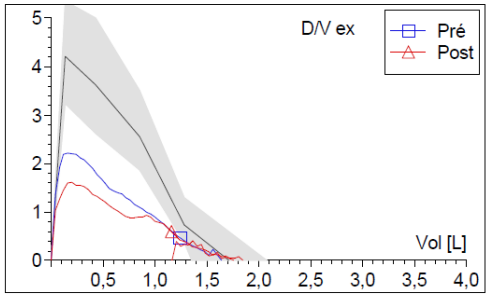
FEV_1: forced expiratory volume in one second; FVC: forced vital capacity.

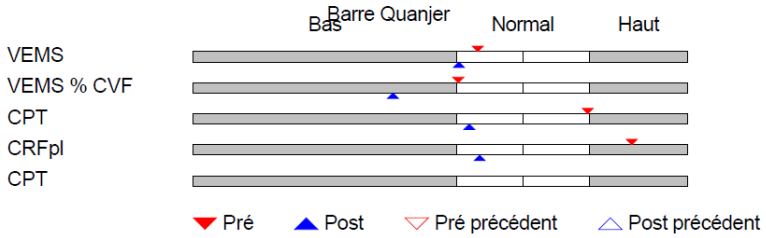
Mucoviscidose

Ethnie:	**Africaine**	**Date naissance:**	**11/09/2008**
Age:	**8 Années**	**Sexe:**	**masculin**
Taille:	**133 cm**	**IMC:**	**15**
Poids:	**27.0 kg**	**Opérateur:**	**CHRYSTELLE**
Méd. traitant:	**Dr HOUDOUIN**	**Médecin:**	**DR DELCLAUX**
Module val.théo:	**GLI-Koopman**		

Date mesure	04.07.17

SaO2 (%): 100





Spirométrie +- bronchodilatateur (salbutamol 400 µg: postBD)
Norme (depuis début avril 2016) : GLI2012, adaptée à l'ethnie

		LIN	Base	% Théo	Z score
VEMS	**L**	1.18	1.24	82	-1.36
CVF	**L**	1.35	1.61	94	-0.46
VEMS%CV	**%**	77.39	76.75	87	-1.73
DPE	**L/s**	3.23	2.21	53	-3.37
DEMM	**L/s**	1.07	1.06	59	-1.67

Résistances (pléthysmographie et/ou impulsométrie) +- bronchodilatateu
Normes (depuis sept 2016) :Raw :Koopman2011; sRaw: Kirkby2010 et im

		LSN	Base	% Théo	Z score
SRawEff	**KPA*S**	1.54	1.17	115	0.49
RawEff	**kPa/(L/s)**	0.89	0.47	76	-1.05

Volumes statiques (pléthysmographie [pl] et/ou dilution [He]) et Capacité
Norme (depuis sept 2016) : Koopman2011 non adaptée à l'ethnie, non ca

		LIN	LSN	Base	% Théo	Z score
CPT	**L**	2.39	3.34	3.40	120	1.85
CRFpl	**L**	1.05	1.89	2.27	159	3.03
VR	**L**	0.42	1.13	1.97	266	5.14
VR%CPT	**%**	16.83	38.81	57.93	217	4.24
CV	**L**	1.72	2.48	1.43	69	-2.99
VRE	**L**	0.31	1.11	0.30	45	-1.66

TVO léger
Distension sévère
Réponse BD sur volumes
Distension dynamique
(idem BPCO adulte)

TABLE 5 Types of ventilatory defects and their diagnoses

Abnormality	Diagnosis
Restriction	TLC <5th percentile of predicted
	A reduced VC does not prove a restrictive pulmonary defect. It may be suggestive of lung restriction when FEV_1/VC is normal or increased
	A low TLC from a single-breath test should not be seen as evidence of restriction
Mixed defect	FEV_1/VC and TLC <5th percentile of predicted

FEV_1: forced expiratory volume in one second; VC: vital capacity; TLC: total lung capacity.

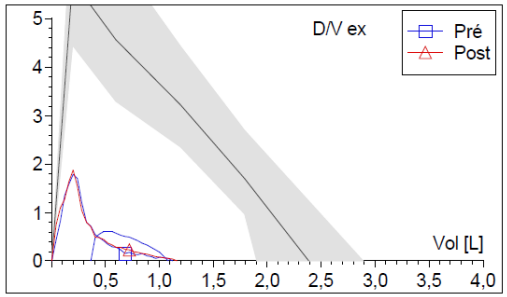
Distension, définition (proposition):

- légère: VR > LSN
- modérée: VR et CRF > LSN
- sévère: VR, CRF et CPT > LSN

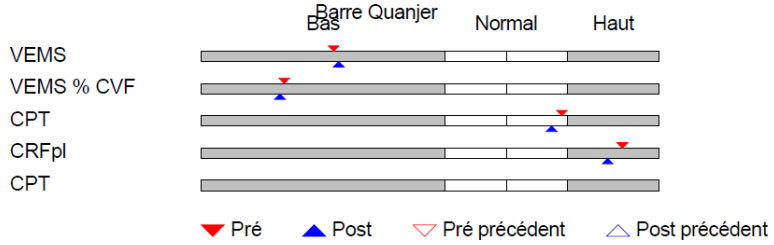
Mucoviscidose

Ethnie:	**Asie SE**	**Date naissance:**	**30/09/2005**
Age:	**13 Années**	**Sexe:**	**féminin**
Taille:	**148 cm**	**IMC:**	**18**
Poids:	**39.0 kg**	**Opérateur:**	**ISA**
Méd. traitant:	**Dr GERARDIN**	**Médecin:**	**Dr PEIFFER**
Module val.théo:	**GLI-Koopman**		

Date visite	17.12.18



SaO2 (%): 97



Spirométrie +- bronchodilatateur (salbutamol 400 µg: postBD)
Norme (depuis début avril 2016) : GLI2012, adaptée à l'ethnie

		Mes. base	LIN	Z score	% Théo	Mes. post BD	Z score	% Théo	Réponse BD%
TEF	**sec**	6.60				5.80			-12
VEMS	**L**	0.64	1.74	-5.25	29	0.68	-5.12	31	7
CVF	**L**	1.15	1.90	-4.37	48	1.25	-4.01	52	8
VEMS%CV	**%**	55.56	83.01	-4.12	60	54.84	-4.15	59	-1
DEMM	**L/s**	0.25	2.08	-5.49	8	0.25	-5.47	8	2

Résistances (pléthysmographie et/ou impulsométrie) +- bronchodilatateur)
Normes (depuis sept 2016) :Raw :Koopman2011; sRaw: Kirkby2010 et impulsométrie:Dencker2006

Interprétation fonctionnelle: exécution: bonne
Présence d'un trouble ventilatoire obstructif (VEMS/CV<LIN)très sévère (VEMS<35% theo)
Absence de réversibilité significative (<12%) sur le VEMS et la CVF
Présence d'une distension thoracique sévère (VR, CRF, CPT augmentés)
Conclusion: Trouble ventilatoire obstructif très sévère sans réversibilité après BDCA. Présence d'une distension thoracique. EFR comparables a celles du 04/12/18.
Sarfati (int)

Volumes statiques (pléthysmographie [pl] et/ou dilution [He]) et Capacité Vitale Lente
Norme (depuis sept 2016) : Koopman2011, non adaptée à l'ethnie, non caucasiens: majorer de 10-15%

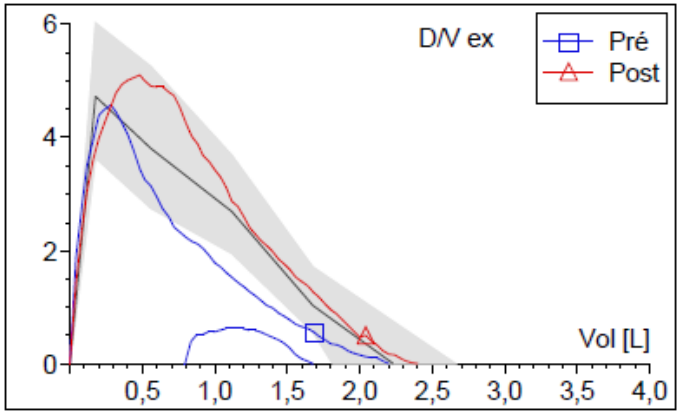
		Mes. base	LIN	LSN	Z score	% Théo	Mes. post BD	Z post BD	% Théo BD	Réponse BD%
CPT	**L**	4.10	2.91	4.08	1.71	119	3.98	1.40	115	-3
CRFpl	**L**	2.91	1.28	2.29	3.48	167	2.77	3.05	159	-5
VR	**L**	2.76	0.46	1.24	7.49	342	2.62	6.94	324	-5
VR%CPT	**%**	67.35	14.36	33.13	7.09	296	65.67	6.82	288	-2
CV	**L**	1.34	2.22	3.20	-4.80	50	1.37	-4.70	51	2
VRE	**L**	0.15	0.48	1.50	-2.81	16	0.15	-2.81	16	0

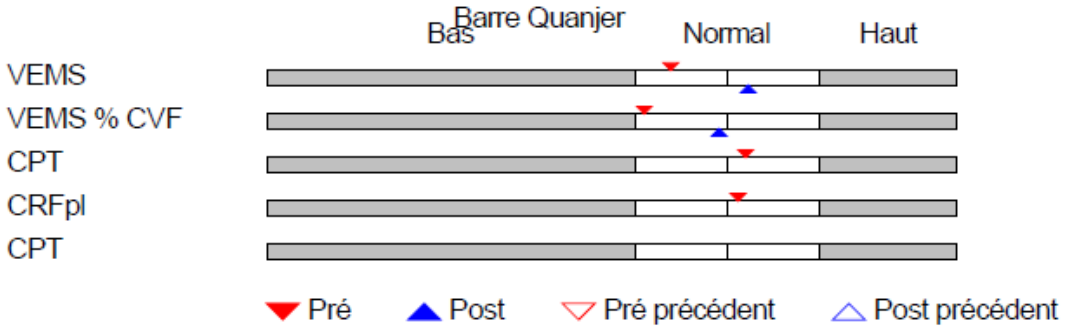
Indication: suivi de maladie asthmatique

Spirométrie +- bronchodilatateur (salbutamol 400 µg: postBD)
Norme (depuis début avril 2016) : GLI2012, adaptée à l'ethnie

		LIN	Base	% Théo	Z score
VEMS	L	1.57	1.67	86	-1.20
CVF	L	1.81	2.19	98	-0.16
VEMS%CV	%	75.97	76.17	88	-1.62
DPE	L/s	3.63	4.59	97	-0.20
DEMM	L/s	1.52	1.33	58	-2.11

Interprétation ?





Spirométrie +- bronchodilatateur (salbutamol 400 µg: postBD)
Norme (depuis début avril 2016) : GLI2012, adaptée à l'ethnie

		LIN	Base	% Théo	Z score	Post BD	% Théo	Z score	Réponse BD%
VEMS	**L**	1.57	1.67	86	-1.20	2.03	105	0.47	22
CVF	**L**	1.81	2.19	98	-0.16	2.37	106	0.52	8
VEMS%CV	**%**	75.97	76.17	88	-1.62	85.86	99	-0.15	13
DPE	**L/s**	3.63	4.59	97	-0.20	5.09	108	0.48	11
DEMM	**L/s**	1.52	1.33	58	-2.11	2.33	101	0.06	75

Diminution isolée, significative de DEMM (< -1.64 z-score)

Obstruction bronchique minime (et non périphérique)

The earliest change associated with airflow obstruction in small airways is thought to be a slowing in the terminal portion of the spirogram, even when the initial part of the spirogram is barely affected [45–47]. This slowing of expiratory flow is most obviously reflected in a concave shape on the flow–volume curve. Quantitatively, it is reflected in a proportionally greater reduction in the instantaneous flow measured after 75% of the FVC has been exhaled ($FEF_{75\%}$) or in mean expiratory flow between 25% and 75% of FVC than in FEV_1. However, abnormalities in these mid-range flow measurements during a forced exhalation are not specific for small airway disease in individual patients [48].

Pas de définition de la concavité …
Obstruction débutante (minime)
Pas d'atteinte spécifiquement périphérique

Forced expiratory flows' contribution to lung function interpretation in schoolchildren

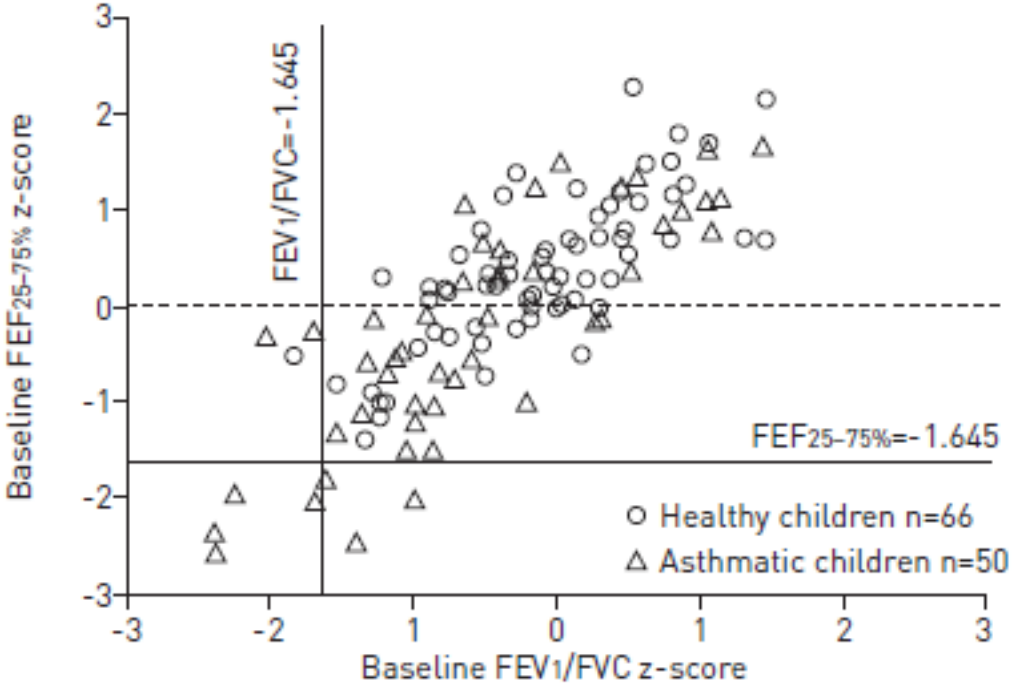
Eur Respir J 2015; 45: 107–115

Bernard Boutin[1], Marc Koskas[2], Houda Guillo[2], Lucia Maingot[2], Marie-Claude La Rocca[2], Michèle Boulé[2], Jocelyne Just[1,3], Isabelle Momas[4,5], Alberti Corinne[6] and Nicole Beydon[2,7]

Norme: GLI
50 asthmatiques
66 normaux
âge moyen 8 ans

TABLE 2 Baseline spirometry readings in the healthy and asthmatic children

	Healthy children#				Asthmatic children¶		
	Absolute values	z-scores	Intra-measure CV %	Inter-subject CV %	Absolute value	z-scores	Intra-measure CV %
FVC L	1.84 (1.69–2.04)	0.37 (−0.04–0.82)	2.4 (1.5–3.6)	13	1.92 (1.65–2.15)	0.08 (−0.37–0.76)	2.0 (1.3–2.7)
FEV_1 L	1.62 (1.49–1.77)	0.36 (−0.08–0.96)	1.9 (1.4–3.2)	11.8	1.57 (1.43–1.80)	−0.09 (−1.01–0.66)***	2.1 (1.4–2.9)
FEV_1/FVC	0.88 (0.85–0.91)	−0.09 (−0.56–0.39)			0.85 (0.79–0.90)	−0.68 (−1.27–0.24)**	
PEF $L \cdot s^{-1}$	3.69 (3.32–3.95)	NA	4.2 (2.8–6.3)	12.7	3.70 (3.14–4.26)	NA	4.0 (2.6–5.2)
$FEF_{25-75\%}$ $L \cdot s^{-1}$	2.08 (1.87–2.37)	0.33 (−0.06–0.80)	4.1 (2.8–6.7)	18.9	1.83 (1.51–2.28)	−0.21 (−1.04–0.65)***	4.3 (2.7–7.3)



2 asthmatiques (1.7%)
Diminution isolée de $DEM_{25-75\%}$

Conclusion:

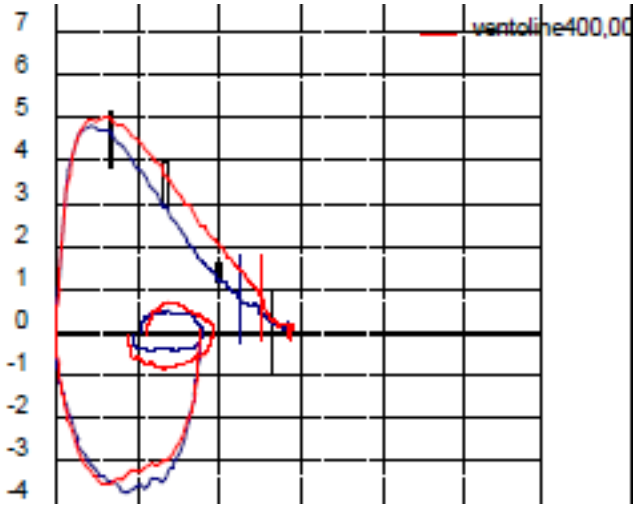
L'analyse des débits instantanés apporte très peu par rapport à l'analyse de VEMS/CVF
que ce soit chez l'enfant (ou l'adulte)
(le seul débit instantané disponible dans GLI: $DEM_{25-75\%}$)

Quand tester la réversibilité ?

Indication: suivi de maladie asthmatique persitant léger

Spirométrie (norme GLI2012, adaptée à l'ethnie)

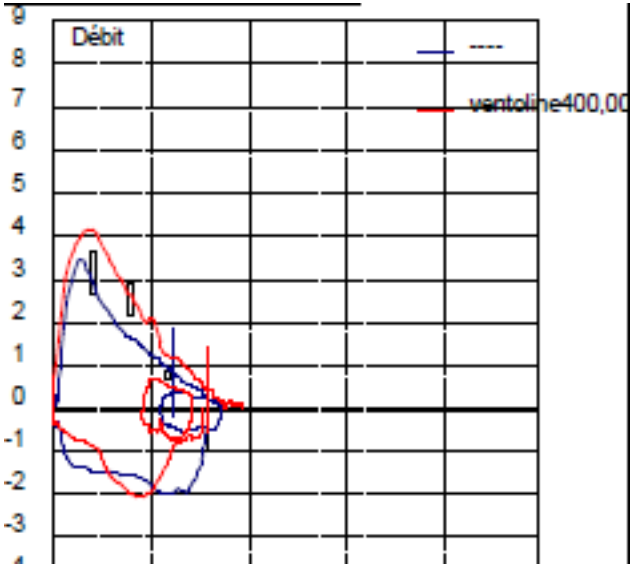
	LLN	Pré Mes.	Pré %Norme	Pré Z-Score	Post Mes.	Post %Norme ventoline	Post Z-Score 400 ug	Dif. Pré%
VEMs(L)	1,86	2,29	99	-0,10	2,56	111	0,91	12
CVF(L)	2,15	2,87	108	0,69	2,91	110	0,80	1
VEMs/CVF(%)	77	80	90	-1,36	88	100	-0,02	
DEP(L/S)	4,17	4,78	88	-0,80	4,99	92	-0,53	
DEM(L/S)	1,84	2,11	75	-1,16	2,96	105	0,21	



Faut il réaliser un test BD ?

Pas de concavité très évidente, z-score VEMS/CV -1.36

	LLN	Pré Mes.	Pré %Norme	Pré Z-Score	Post Mes.	Post %Norme ventoline	Post Z-Score 400 ug	Dif. Pré%
VEMs(L)	1,07	1,41	102	0,15	1,59	115	1,15	13
CVF(L)	1,21	1,77	115	1,09	1,93	125	1,87	9
VEMs/CVF(%)	79	80	89	-1,63	82	91	-1,32	
DEP(L/S)	2,28	3,47	100	0,01	4,17	120	0,89	
DEM(L/S)	1,32	1,60	77	-1,02	2,20	106	0,25	



Réversibilité significative
En dépit de l'absence de TVO significatif…

La solution est-elle de systématiquement tester la réversibilité ?

Should reversibility be assessed in all asthmatic children with normal spirometry?

ERJ Express. Published on May 31, 2018

Edouard Dufetelle, Plamen Bokov, Christophe Delclaux, Nicole Beydon

Table 1- Characteristics of the 5,238 pulmonary function tests with normal baseline spirometry according to bronchodilator response

5,238 PFT in 2,343 children 1,149 children tested once 474 children tested twice 302 children tested thrice 418 tested more than thrice	Negative BD response, n=4,983		Positive BD response, n=255		Difference between responsive and non-responsive cases	
	Value or Mean	SD	Value or Mean	SD	Mean	95%CI
Sex, % boys	61.6		65.9			
Age, years	10.7	2.9	10.0	3.1	-0.7	[-1.1 ; -0.3]
ICS controller, % cases	75.3		64.3		-11.0	[-16.5 ; -5.5]
Spirometry						
Baseline						
FEV_1, L	2.19	0.74	1.92	0.75	-0.27	[-0.36 ; -0.17]
FEV_1, Z score	0.06	0.91	-0.53	0.68	-0.58	[-0.67 ; -0.50]
FVC, L	2.58	0.9	2.36	0.98	-0.22	[-0.34 ; -0.10]
FVC, Z score	0.28	0.90	-0.01	0.75	-0.28	[-0.38 ; -0.19]
FEV_1/FVC	0.85	0.05	0.82	0.05	-0.03	[-0.04 ; -0.02]
FEV_1/FVC, Z score	-0.43	0.77	-0.95	0.60	-0.52	[-0.60 ; -0.45]

Réponse BD significative: 4.9% (IC95%: 4.3-5.5)

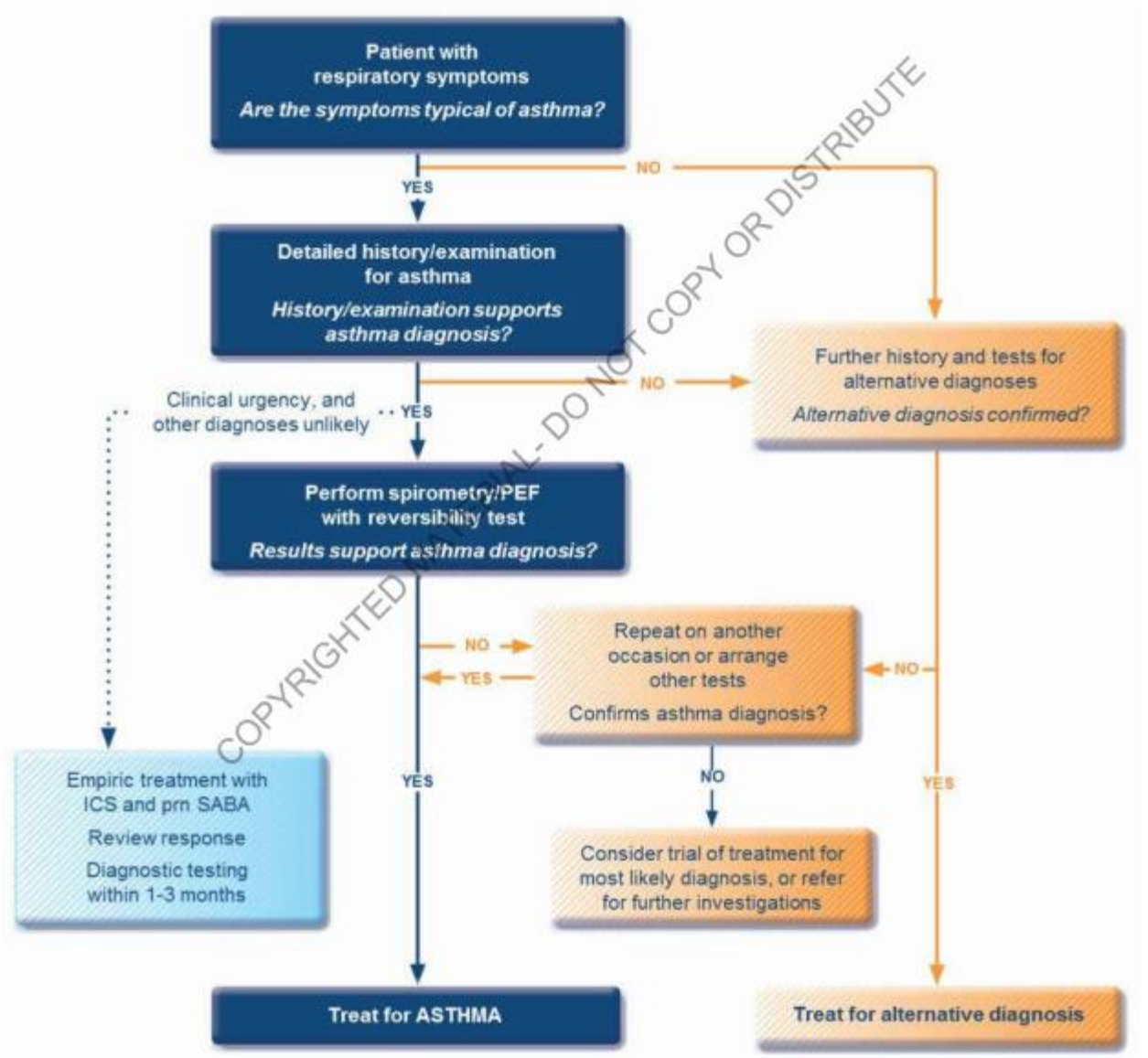
Quand tester éventuellement réversibilité ?

- Z-score VEMS < +0.42
- Z-score VEMS/CVF < -0.16

Updated 2019

Nécessité de démontrer la réversibilité d'un TVO ou trouble bronchomoteur (si absence de TVO)

Box 1. Diagnostic flow-chart for asthma in clinical practice



The **diagnosis of asthma** should be confirmed and, for future reference, the evidence documented in the patient's notes. This should preferably be done before starting controller treatment. Confirming the diagnosis of asthma is more difficult after treatment has been started (see p11).

HOW TO CONFIRM THE DIAGNOSIS IN PATIENTS TAKING CONTROLLER TREATMENT

For many patients (25–35%) with a diagnosis of asthma in primary care, the diagnosis cannot be confirmed. If the basis of the diagnosis has not already been documented, confirmation with objective testing should be sought.

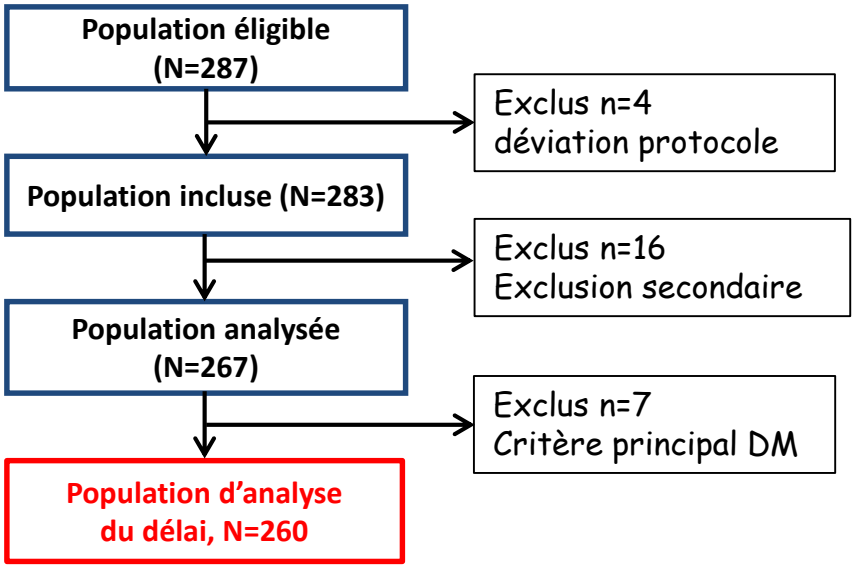
If standard criteria for asthma (Box 2, p.9) are not met, consider other investigations. For example, if lung function is normal, repeat reversibility testing when the patient is symptomatic, or after withholding bronchodilator medications for >12 hours (24 hours if ultra-long-acting). If the patient has frequent symptoms, consider a trial of step-up in controller treatment and repeat lung function testing after 3 months. If the patient has few symptoms, consider stepping down controller treatment; ensure the patient has a written asthma action plan, monitor them carefully, and repeat lung function testing.

Arrêt des bronchodilatateurs le matin de l'EFR
Tant que la réversibilité n'est pas démontrée
Quel délai pour les BDLA ?

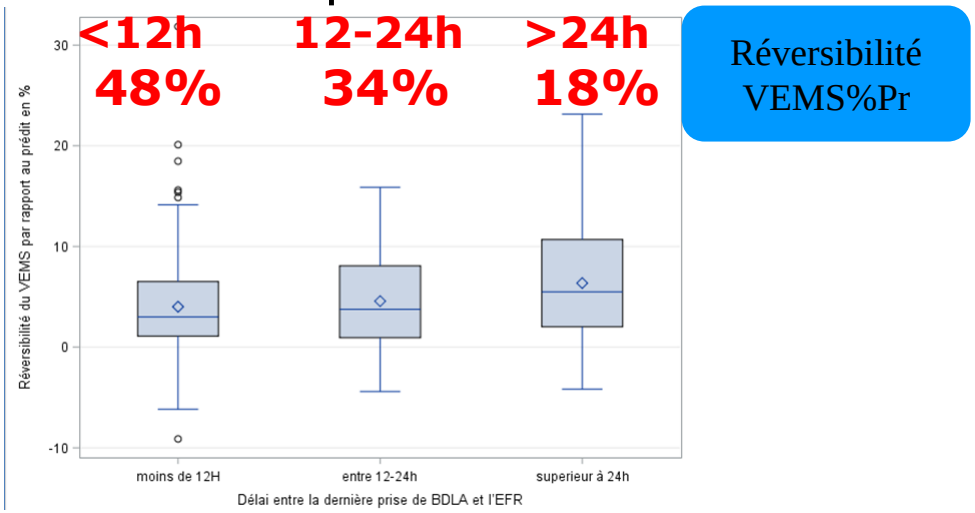
Effect of long-acting β-agonist on bronchodilator response in children with asthma

Eur Respir J 2020; 56: 1902010

Jessica Taytard[1,2], Camille Aupiais[3,4], Sophie Jovien[5], Jessica Assouline Kabla[5], Noémie Haziot[5], Marilyn Fuger[5], Corinne Alberti[3,4,6] and Nicole Beydon[2,5]



Dernière prise BDLA



Réversibilité VEMS%Pr

- Etude prospective
  - Asthme typique tt BDLA
  - Age: 12,2 [IQR:9,6;14,9]
  - Asthme
    - Contrôlé 85%
    - Partiellement contrôlé 12%
    - Non contrôlé 3%
  - Exa depuis 3 mois 37%
  - Évaluation tech inhalation
    - Bonne 85%
  - Symbicort 33%
  - Sérétide AD 50%/PI 17%

Délai entre dernière prise BDLA et test au BD

TABLE 1 Baseline and post-bronchodilator spirometry, and bronchodilator response in three groups of children according to the delay since last long-acting β2-agonist dose

	<12 h (n=126)	12–24 h (n=88)	>24 h (n=46)	p-value
Baseline FVC (z-score)	0.14 (−0.47 to 0.82)	0.03 (−0.69 to 0.79)	0.07 (−0.49 to 0.66)	
Baseline FEV_1 (z-score)	−0.24 (−0.89 to 0.46)	−0.37 (−0.92 to 0.58)	−0.55 (−1.38 to 0.10)	0.079
Baseline FEV_1/FVC (z-score)	−0.67 (−1.53 to 0.05)	−0.84 (−1.28 to 0.32)	−1.05(−1.94 to −0.34)	0.047
Baseline obstruction	26 (21)	15 (17)	16 (35)	0.055
Post-BD FVC (z-score)	0.15 (−0.48 to 0.83)	−0.09 (−0.62 to 0.79)	0.19 (−0.44 to 0.67)	
Post-BD FEV_1 (z-score)	0.12 (−0.61 to 0.73)	0.08 (−0.57 to 0.91)	−0.14 (−0.53 to 0.55)	0.445
Post-BD FEV_1/FVC (z-score)	−0.27 (−0.84 to 0.72)	0.11 (−0.82 to 0.65)	−0.13(−1.01 to 0.31)	0.317
FEV_1 BDR ⩾12% pred	10 (8)	4 (5)	7 (15)	0.098

	OR [IC95%]	P-value
Délai de la dernière prise de BDLA		
Moins de 12h	1	
Entre 12h et 24h	0.54 [0.13 ; 2.16]	0.381
Supérieur à 24h	1.38 [0.41 ; 4.64]	0.605
Dose finale		
Demi-dose	1	
Simple ou double dose	0.24 [0.08 ; 0.77]	**0.016**
VEMS en z-score		
< -1.64 DS	1	
≥ -1.64 DS	0.14 [0.04 ; 0.53]	**0.003**
Rapport VEMS / CVF en z-score		
< -1.64 DS	1	
≥ -1.64 DS	0.24 [0.08 ; 0.75]	**0.014**

modèle de régression logistique: réponse BD variable dépendante

Pas d'effet du délai

Taytard *ERJ* 2020

Recommandations GINA

Box 4. Assessment of symptom control and future risk

A. Level of asthma symptom control

In the past 4 weeks, has the patient had:		Well controlled	Partly controlled	Uncontrolled
Daytime symptoms more than twice/week?	Yes☐ No☐			
Any night waking due to asthma?	Yes☐ No☐	None of these	1–2 of these	3–4 of these
Reliever needed more than twice/week?	Yes☐ No☐			
Any activity limitation due to asthma?	Yes☐ No☐			

B. Risk factors for poor asthma outcomes

Assess risk factors at diagnosis and periodically, at least every 1-2 years, particularly for patients experiencing exacerbations.

Measure FEV_1 at start of treatment, after 3–6 months of controller treatment to record personal best lung function, then periodically for ongoing risk assessment.

Having uncontrolled asthma symptoms is an important risk factor for exacerbations

Additional potentially modifiable risk factors for exacerbations, even in patients with few asthma symptoms, include:

- *Medications*: ICS not prescribed; poor adherence; incorrect inhaler technique; high SABA use (with increased mortality if >1x200-dose canister/month)
- *Comorbidities*: obesity; chronic rhinosinusitis; gastro-esophageal reflux disease; confirmed food allergy; anxiety; depression; pregnancy
- *Exposures*: smoking; allergen exposure if sensitized; air pollution
- *Setting*: major socioeconomic problems
- *Lung function*: low FEV_1, especially if <60% predicted; higher reversibility
- *Other tests*: sputum/blood eosinophilia; elevated FENO in allergic adults on ICS

Other major independent risk factors for flare-ups (exacerbations) include:

- Ever being intubated or in intensive care for asthma
- Having 1 or more severe exacerbations in the last 12 months.

Having any of these risk factors increases the patient's risk of exacerbations ***even if they have few asthma symptoms***.

Risk factors for developing fixed airflow limitation include preterm birth, low birth weight and greater infant weight gain; lack of ICS treatment; exposure to tobacco smoke, noxious chemicals or occupational exposures; low FEV_1; chronic mucus hypersecretion; and sputum or blood eosinophilia

Risk factors for medication side-effects include:

- *Systemic*: frequent OCS; long-term, high dose and/or potent ICS; also taking P450 inhibitors
- *Local*: high-dose or potent ICS; poor inhaler technique

Déterminer la meilleure fonction personnelle

Facteurs de risque de TVO fixé

What is the role of lung function in monitoring asthma?

Once asthma has been diagnosed, lung function is most useful as an indicator of future risk. It should be recorded at diagnosis, 3–6 months after starting treatment, and periodically thereafter. Most patients should have lung function measured at least every 1-2 years, more often in children and those at higher risk of flare-ups or lung function decline. Patients who have either few or many symptoms relative to their lung function need more investigation.

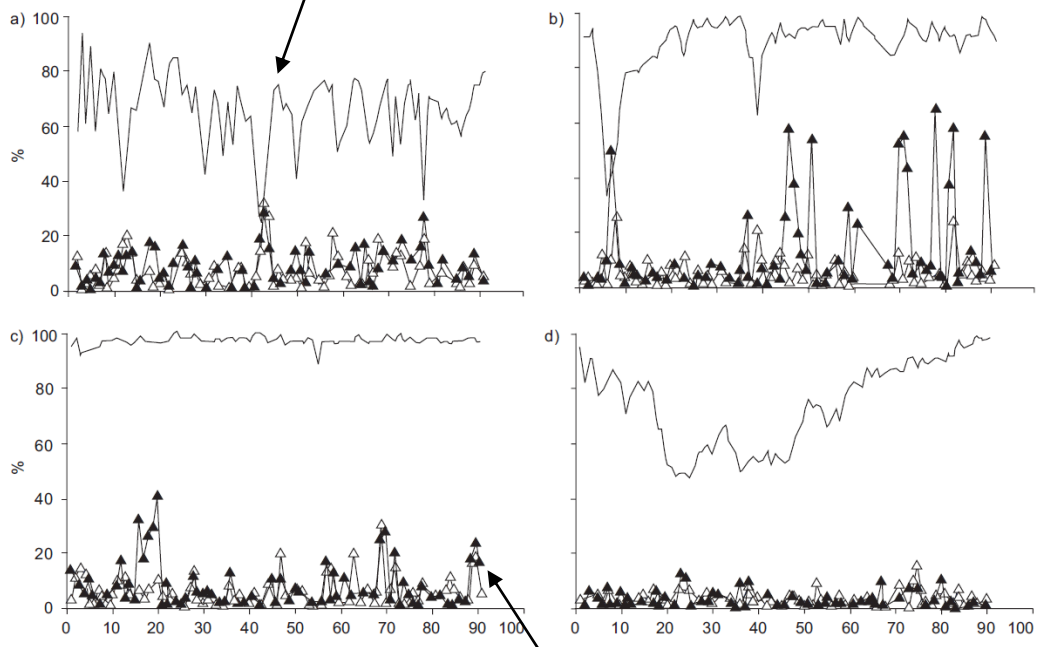
Une fois le diagnostic posé
EFR après 3 à 6 mois
Puis tous les 1 à 2 ans
Pas d'arrêt des traitements le jour de l'EFR

Contrôle de l'asthme et fonction respiratoire

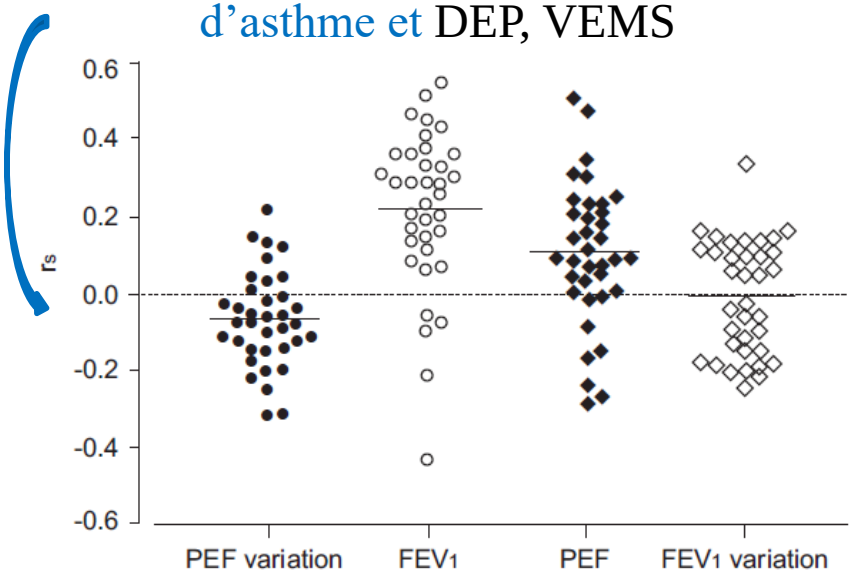
L'asthme est fréquemment mal contrôlé
Le VEMS est fréquemment dans les limites de la normale

3 mois de recueil quotidien 36 enfants
asthme léger à modéré
- score d'asthme, DEP, VEMS

Variation des symptômes d'asthme, % meilleur



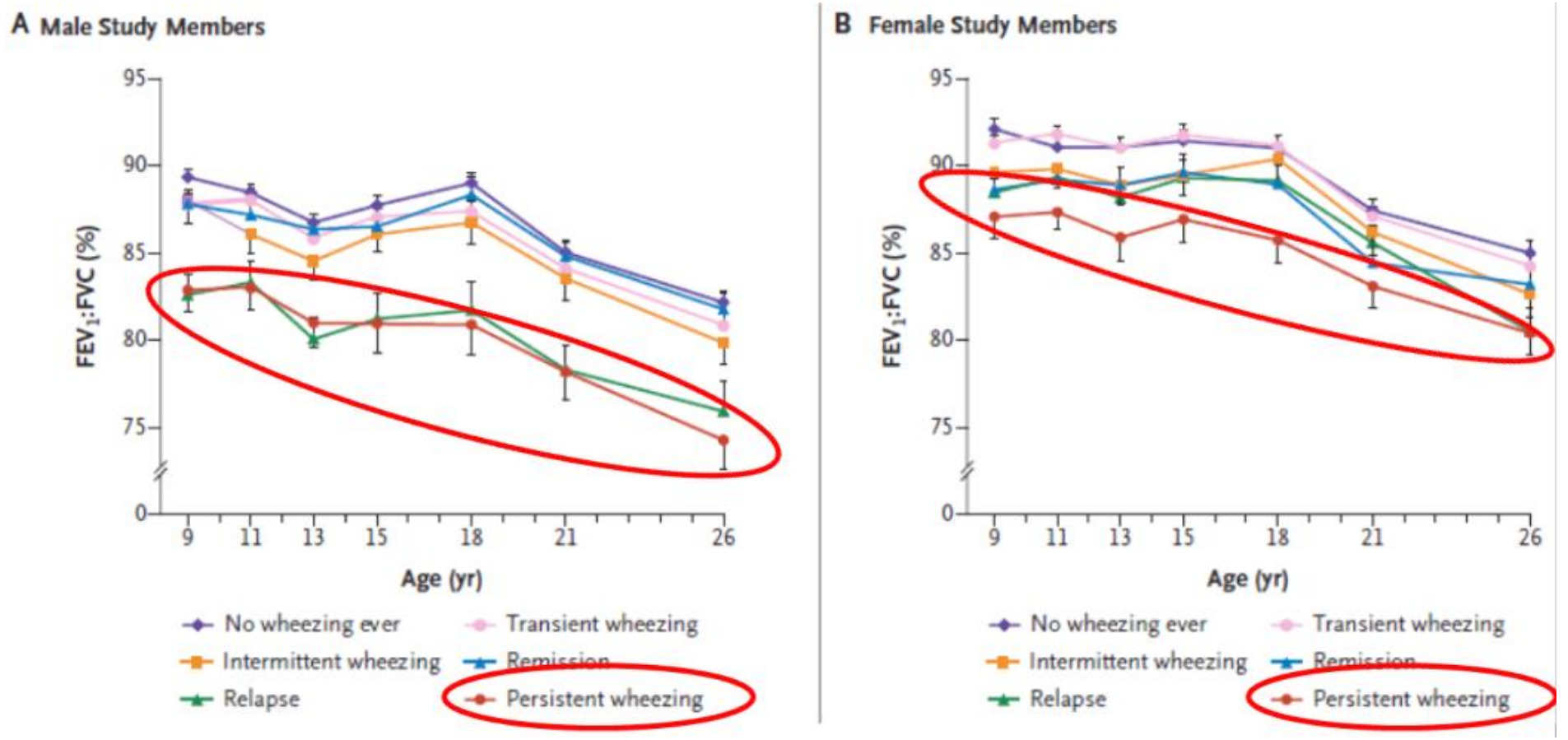
Faible corrélation entre symptômes d'asthme et DEP, VEMS



DEP & VEMS ne sont pas de bons indicateurs du contrôle de l'asthme

Bouwer *ERJ* 2006

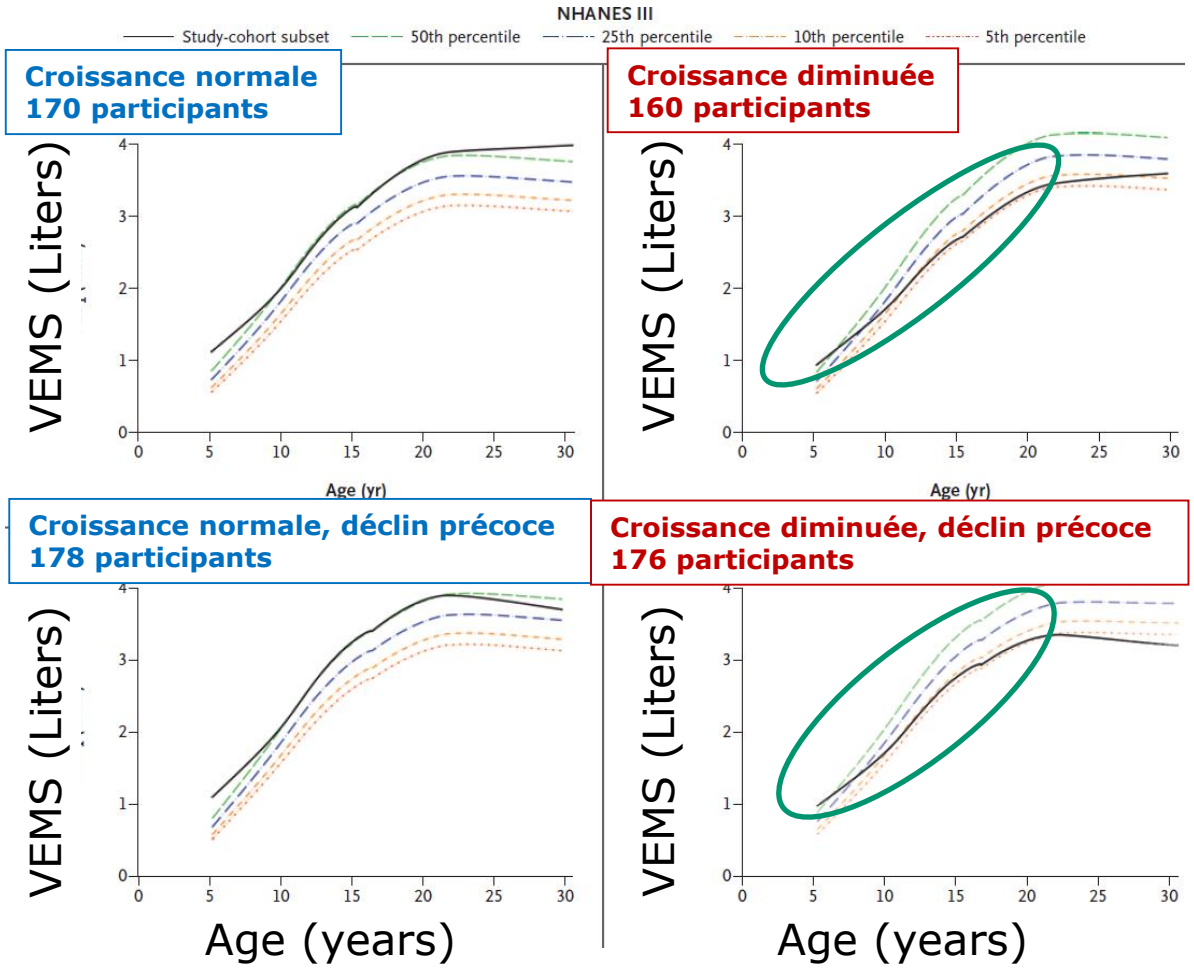
Persistance de l'atteinte fonctionnelle ans selon le phénotype entre 9 et 26



Sears *NEJM* 2003

VEMS pour évaluer le risque futur

Suivi de l'enfance jusqu'à la trentaine d'asthmatiques léger-modérés



Croissance normale
n=348

Croissance réduite
n=336

A l'inclusion

Plus jeune
Garçons
Niveau SE plus bas

VEMS plus bas
RBD moindre
HRB plus importante

Risque de BPCO, prévention ciblée du tabagisme

McGeachie *NEJM* 2016

Quelles explorations chez l'enfant en préscolaire (moins de 6 ans), ne réalisant pas de spirométrie ?

Principe:

Faire une mesure en ventilation courante
Ne nécessitant pas de manœuvre respiratoire particulière
Hors acceptation de l'embout buccal…

3 méthodes disponibles:

- Mesure de résistance par interruption du débit (occlusion)
- Mesure de résistance spécifique en pléthysmographie
- Mesure de résistance par oscillations forcées

Les mesures spécifiques de l'enfant préscolaire de 3 à 6 ans

An Official American Thoracic Society/European Respiratory Society Statement: Pulmonary Function Testing in Preschool Children

Nicole Beydon, Stephanie D. Davis, Enrico Lombardi, Julian L. Allen, Hubertus G. M. Arets, Paul Aurora, Hans Bisgaard, G. Michael Davis, Francine M. Ducharme, Howard Eigen, Monika Gappa, Claude Gaultier, Per M. Gustafsson, Graham L. Hall, Zoltán Hantos, Michael J. R. Healy, Marcus H. Jones, Bent Klug, Karin C. Lødrup Carlsen, Sheila A. McKenzie, François Marchal, Oscar H. Mayer, Peter J. F. M. Merkus, Mohy G. Morris, Ellie Oostveen, J. Jane Pillow, Paul C. Seddon, Michael Silverman, Peter D. Sly, Janet Stocks, Robert S. Tepper, Daphna Vilozni, and Nicola M. Wilson, on behalf of the American Thoracic Society/ European Respiratory Society Working Group on Infant and Young Children Pulmonary Function Testing

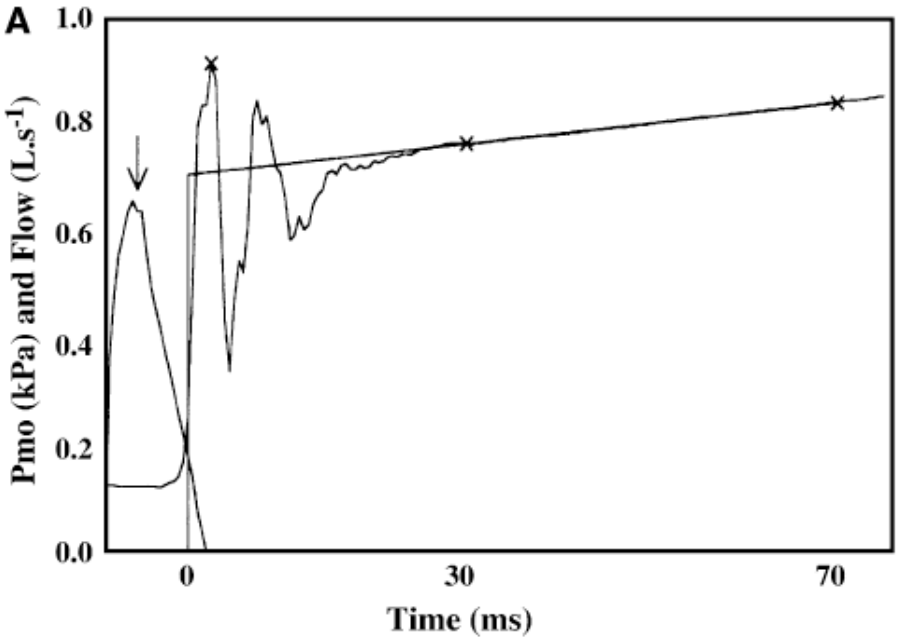
This official statement of the American Thoracic Society (ATS) and the European Respiratory Society (ERS) was approved by the ATS Board of Directors, September 2006, and the ERS Executive Committee, December 2006

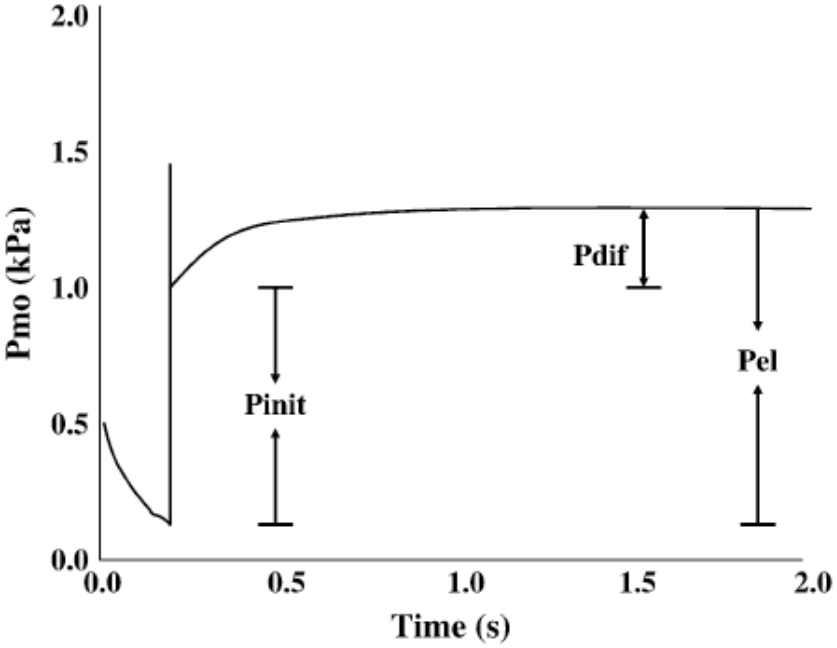
Résistance par interruption (de débit): Rint

Principe (description en 1927):

- respiration calme (dès 3 ans)
- mesure du débit ventilatoire
- courtes (100 ms) interruptions (expiratoires / inspiratoires)
- mesure de pression d'occlusion (bouche) ~ pression alvéolaire
- calcul de la « résistance »

Pinit = résistance VA + tissu + paroi





Baseline and Post-Bronchodilator Interrupter Resistance and Spirometry in Asthmatic Children

Pediatric Pulmonology 47:987–993 (2012)

Nicole Beydon, MD,[1,2*] Bruno Mahut, MD,[2,3] L. Maingot, MD,[1] H. Guillo, MD,[1] M.C. La Rocca, MD,[1] N. Medjahdi, MD,[1] M. Koskas, MD,[1] M. Boulé, MD, PhD,[1,4] and Christophe Delclaux, MD, PhD[2,3,5,6]

695 enfants asthmatiques
mesure de Rint et spirométrie

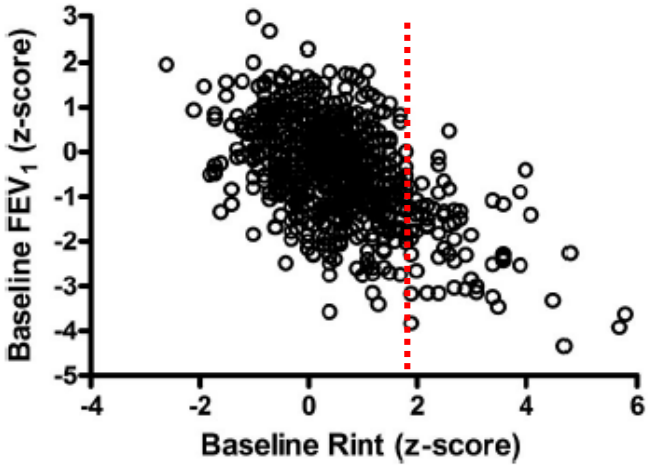


Fig. 3. Relationship between baseline R_{int} and FEV_1 expressed as z-score, in 695 asthmatic children.

bonne spécificité
mauvaise sensibilité
de la Rint pour
détecter une
diminution de VEMS

Résistance pléthysmographique

Mesure la plus utilisée en ville
Description ancienne (1956)

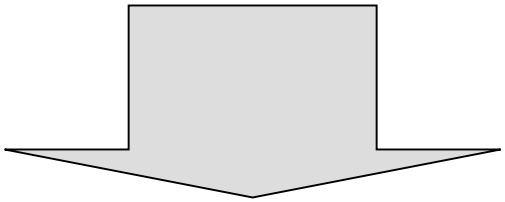
Avantages:
- méthode rapide
- utilisable en ventilation courante (nouveaux appareils)
- mesure de la seule sRaw chez le petit (3-6 ans)
- mesure de la CRF et Raw chez les plus grands (> 6 ans)

sRaw: résistance spécifique (unité kPa.s: viscosité dynamique)
Mesure de petites modifications de pression (ou volume) dans l'enceinte en phase avec la respiration. Ces modifications sont liées à des phénomènes de compression/décompression du gaz intrathoracique (s'accompagnant de modifications de pression/volume dans l'enceinte du pléthysmographe car P.V est constant), liés à obstacle à l'écoulement gazeux constitué par la résistance des voies aériennes.

VGT:
Le second temps de la mesure de Raw consiste à mesurer le volume gazeux intrathoracique (VGT) permettant de calculer la capacité résiduelle fonctionnelle (CRF) lors du temps d'occlusion des voies aériennes. Ce second temps permet de rapporter le phénomène de compression/décompression observé au volume pulmonaire auquel il a été mesuré.

On mesure donc sRaw puis le VGT et on calcule la Raw (sRaw / VGT)

Airflow resistance is rarely used to identify airflow obstruction in clinical practice. It is more sensitive for detecting narrowing of extrathoracic or large central intrathoracic airways than of more peripheral intrathoracic airways [47]. It may be useful in patients who are unable to perform a maximal forced expiratory manoeuvre.



Mesure de la résistance spécifique chez les enfants

sRaw = Raw x CRF en kPa.s (unité de viscosité)
sRaw n'est pas une résistance (résistance x volume)

Relationships between Specific Airway Resistance and Forced Expiratory Flows in Asthmatic Children

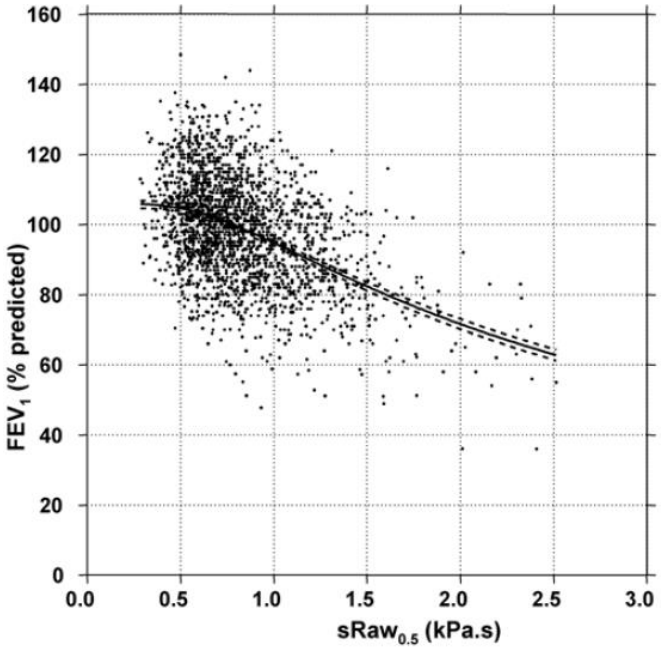
Bruno Mahut[1,2,3,7], Ludovic Trinquart[4,5,7,8], Plamen Bokov[2,4,6,7], Muriel Le Bourgeois[3], Serge Waernessyckle[3], Claudine Peiffer[2,7], Christophe Delclaux[2,4,7]*

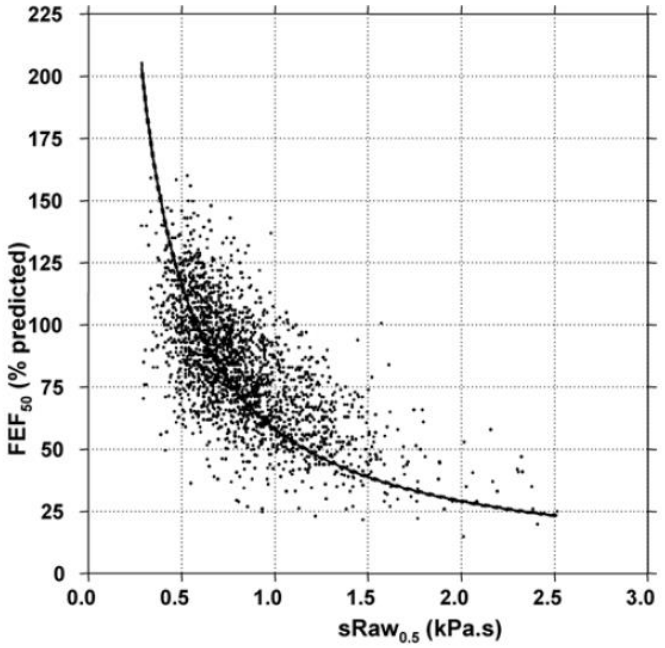
PLoS ONE | www.plosone.org April 2009 | Volume 4 | Issue 4 | e5270

Table 1. Clinical and functional characteristics of the asthmatic children.

Characteristic	
Median [interquartile]	
Number of patients	**2193**
Sex ratio, girls/boys	841/1352
age, years	10.8 [9.0–12.8]
height, cm	144 [135–155]
weight, kg	36 [30–47]
$sRaw_{0.5}$, kPa.s	0.76 [0.62–0.97]
FEV_1, % predicted	99 [88–108]
FEV_1/FVC, %	84 [79–88]
$FEF_{25-75\%}$, % predicted	82 [66–97]
$FEF_{50\%}$, % predicted	82 [66–99]

Variable	Correlation with $sRaw_{0.5}$ (95% confidence interval)
FEV_1, L	−0.14 (−0.18 to −0.10)
FEV_1, % predicted	−0.39 (−0.43 to −0.36)
$FEF_{25-75\%}$, L/s	−0.49 (−0.52 to −0.46)
$FEF_{50\%}$, L/s	−0.47 (−0.50 to −0.43)
$FEF_{50\%}$, % predicted	−0.64 (−0.67 to −0.62)
FEV_1/FVC, %	−0.59 (−0.62 to −0.56)
$FEF_{25-75\%}$/FVC ratio**	−0.18 (−0.22 to −0.14)





Evaluation of the Forced Oscillation Technique for the Determination of Resistance to Breathing

The Journal of Clinical Investigation Volume 47 1968

ARON B. FISHER, ARTHUR B. DUBOIS, and RICHARD W. HYDE

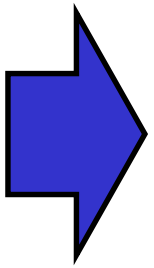
Theoretical aspects. When a sine wave of airflow ($\dot{V}$) is applied to the tracheobronchial air column, the resultant transthoracic pressure (P) changes are related to the total impedance (Z) of the respiratory system:

$$P = Z\,\dot{V}. \qquad (1)$$

Impedance is the vector sum of the effective resistance (R) and the effective reactance (X); the latter in turn is the sum of a component (X_M) related to respiratory inertance and a component (X_C) related to respiratory compliance. In a simple system, the magnitude of X_M is directly proportional to frequency (f) while the magnitude of X_C is inversely proportional to frequency:

$$X_M = 2\pi fM \text{ and} \qquad (2)$$
$$X_C = -1/(2\pi fC)$$

where M is inertance and C is compliance.



Accès au compartiment périphérique

Définition de bronchodilatation significative

Discriminative Capacity of Bronchodilator Response Measured with Three Different Lung Function Techniques in Asthmatic and Healthy Children Aged 2 to 5 Years

KIM G. NIELSEN and HANS BISGAARD

Am J Respir Crit Care Med Vol 164. pp 554–559, 2001

	Asthmatic Subjects	Healthy Controls
n	55	37
Age, yr (range)	4.6 ± 1.0 (2.3–5.9)	3.8 ± 1.0 (2.5–5.9)

TABLE 3. SENSITIVITY, SPECIFICITY, AND PREDICTIVE VALUES OF EACH LUNG FUNCTION TEST BASED ON BRONCHODILATOR RESPONSE AT OPTIMAL CUTOFF LEVEL (INTRASUBJECT STANDARD DEVIATION UNITS) AS THE CUTOFF LEVEL FOR THE DEFINITION OF REVERSIBILITY

Lung Function Test (Cutoff)	Sensitivity (%)	Specificity (%)	Predictive Value of Positive Test (%)	Predictive Value of Negative Test (%)
SRaw (3.0 SDw)	66	81	84	61
Rint (2.5 SDw)	58	70	74	53
Xrs5 (1.5 SDw)	33	89	82	47
Rrs5 (1.0 SDw)	76	65	76	65

sRaw meilleure méthode

Définitions

Définition de l'obstruction bronchique

- VEMS/CV < 5ème percentile ou Z score < -1.645
- Rint > 150% théo ou Z score > +1.645 (ou +1.96)
- sRaw > 150% théo ou Z score > +1.645 (ou +1.96)
- R5Hz > 150% théo

Critères usuels de réponse BD:

- VEMS (ou CVF) ≥ 12% base
- Rint, diminution ≥ 35% prédite
- sRaw, diminution ≥ 50% base
- R5Hz, diminution ≥ 30% base

Quel test à quel âge ?

3 à 6 ans:

Mesure de résistance:
Rint ou Rsr (IOS) ou sRaw selon les habitudes de service
Essai de spirométrie

Après 6 ans:

Spirométrie en première intention
Rint ou Rsr (IOS) ou sRaw si échec

Messages du physiologiste:

Mesure d'impédance (IOS):
chiffrage séparé des propriétés mécaniques (Rsr et Xsr)
sRaw:
Mesure associée de CRF (distension)
Rint:
Mesure globale de mécanique (~impédance)