Assessment of Airway Function in Asthma

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Introduction

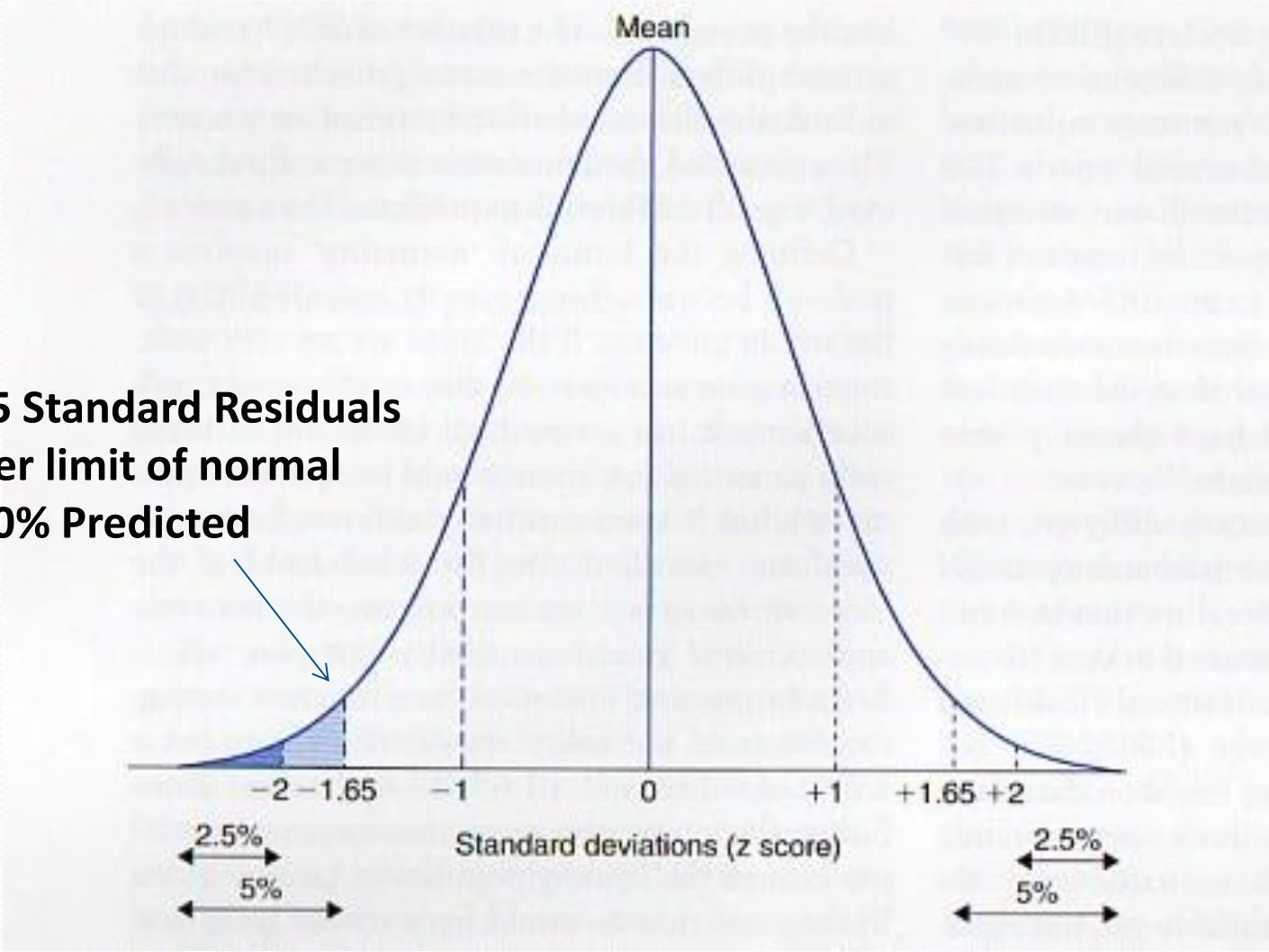
- Guidelines
  - BTS 2016
  - “Confirmation of asthma hinges on demonstration of airflow variability over short periods.”
- Understand normal
- Interpret deviations from normal
- Assess results of standard interventions
- Awareness of alternatives

Expressing Normality

- Percent Predicted
- Lower limit of normal (LLN)
- Standard Residual

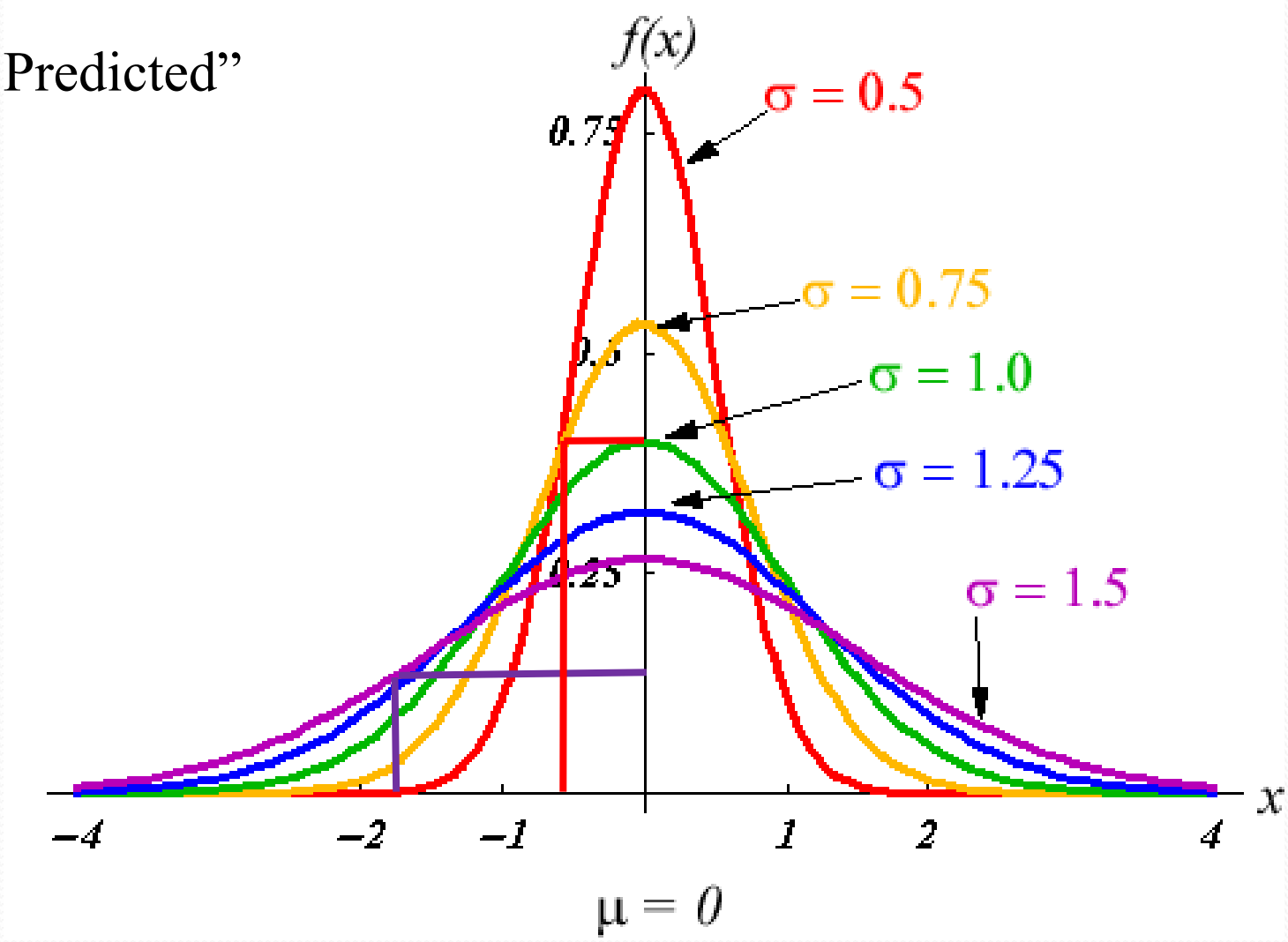
Normal Distribution

-1.65 Standard Residuals
Lower limit of normal
?? 80% Predicted



Normal Distribution(s)

"50% Predicted"



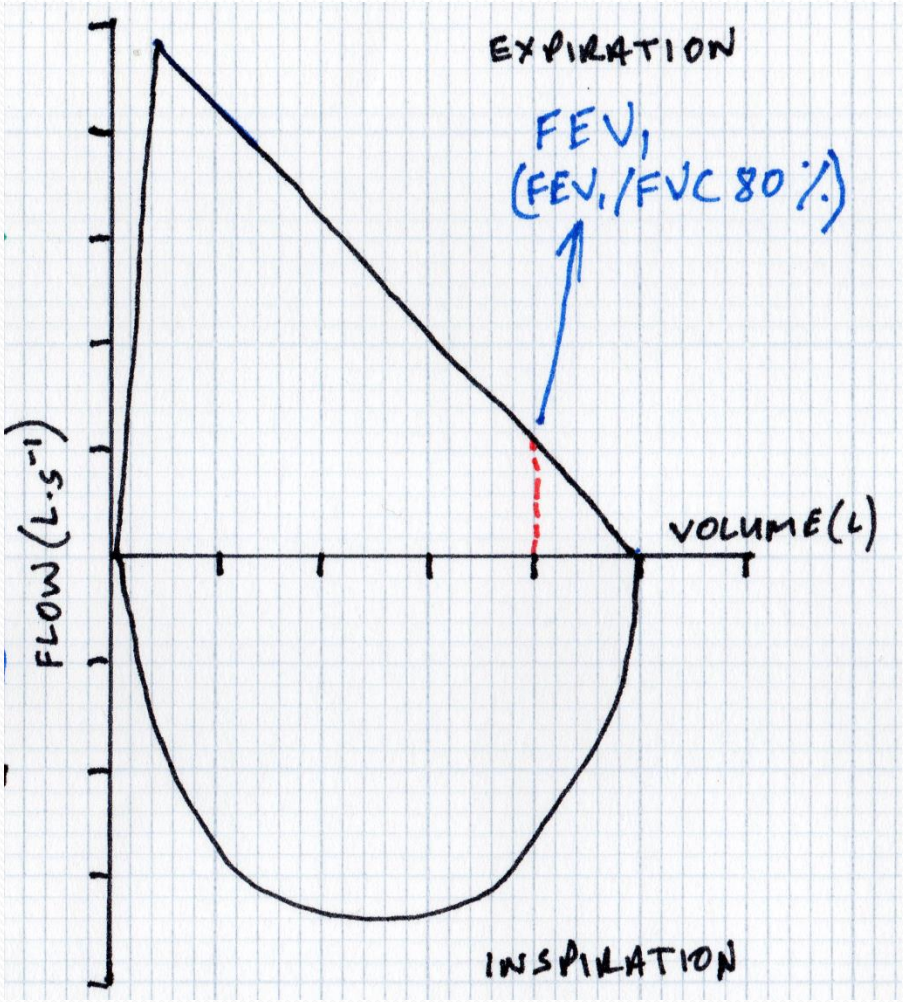
Standard Residual

- The number of standard deviations (Z scores) from the population mean.
- Applicable to all lung function indices

Standard Residual (SR)	Severity
> -1.65	Normal
- 1.65 to -2.50	Mild
- 2.50 to - 3.50	Moderate
< -3.50	Severe

Airway Indices

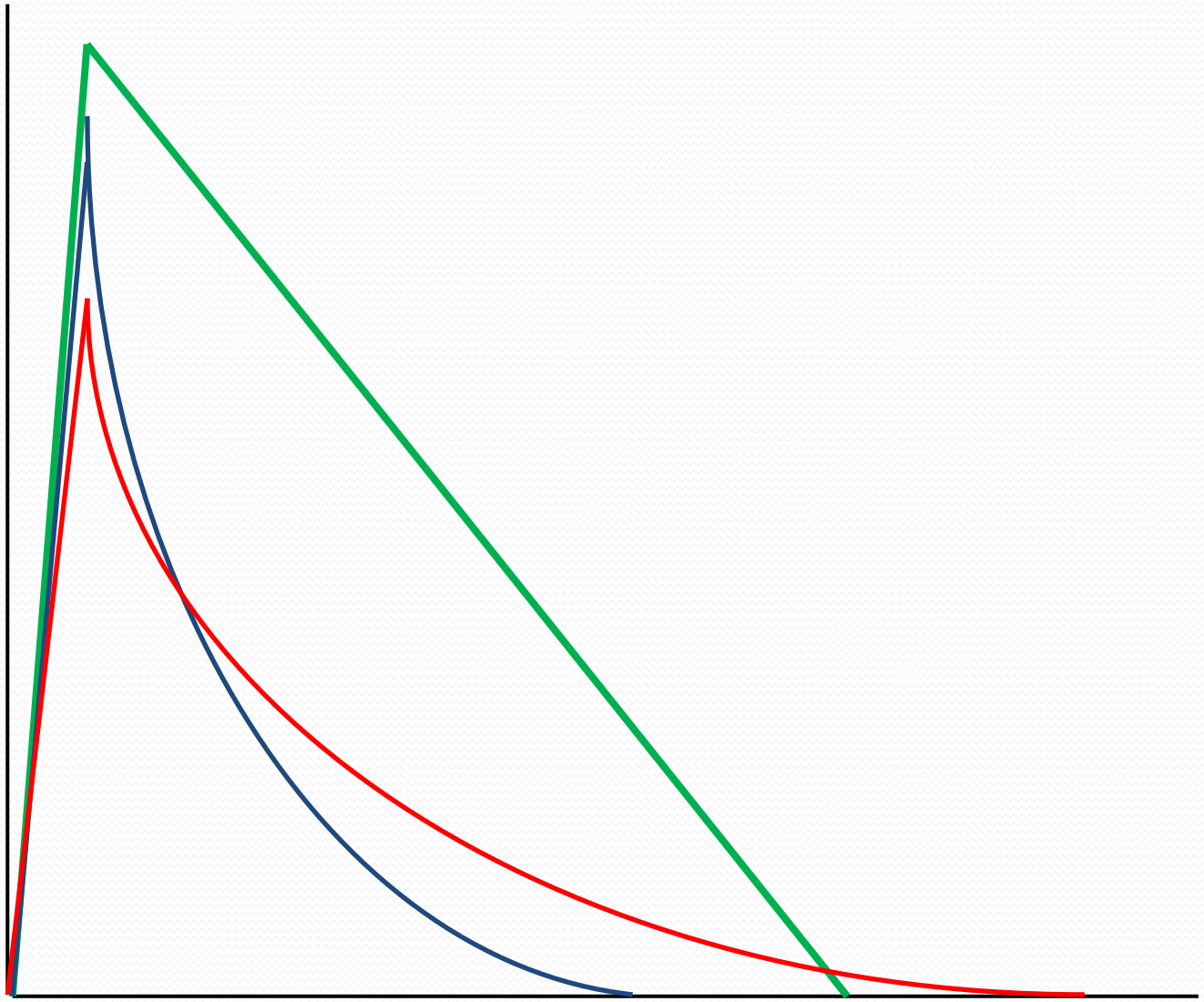
- PEF
- FEV1
- FEV1 Ratio, FEV1/FVC
- “Mid expiratory flows”



The FEV1

- Predominance and Pre-eminence in medical education
- Misleading
  - Reduced in restriction
  - Often “normal” with hyperinflation
- Still recommended to determine severity in COPD
  - Equally misleading
- Learn to hate it

The FEV1



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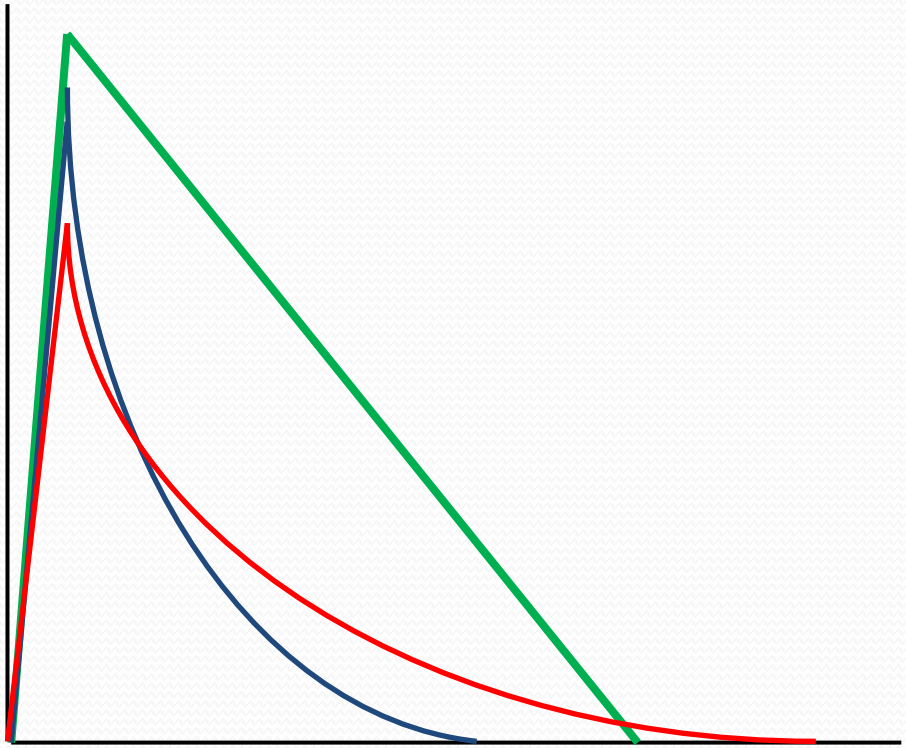
Severity

Post Bronchodilator or FEV_1 Ratio	FEV_1 % Predicted	NICE Clinical Guideline (2010)	GOLD 2008	ATS/ERS 2004	Standard Residual (SR)
> 0.7	> 80%	Normal	Normal	Normal	> - 1.65
< 0.7	≥ 80%	Stage 1 – Mild*	Stage 1 – Mild	Mild	- 1.65 to - 2.50
< 0.7	50 – 79%	Stage 2 – Moderate	Stage 2 – Moderate	Moderate	- 2.50 to - 3.50
< 0.7	30 – 49%	Stage 3 – Severe	Stage 3 – Severe	Severe	< -3.50
< 0.7	< 30%	Stage 4 – Very Severe**	Stage 4 – Very Severe**	Very Severe	-

Severity Interpretation



- FEV1 2.57 (69% pred)
- FVC 3.73 (81% pred)
- Ratio 69% (pred is 78%)
- Moderate obstruction

- FEV1 3.00 (81% pred)
- FVC 6.22 (135% pred)
- **Ratio 48% (pred is 78%)**
- Mild Obstruction

The FEV1 Ratio

- **Primary** index of airflow limitation in spirometry
- Normal Value?

FEV1 Ratio

- 80 year old male, height 1.78m
- Reference FEV1 Ratio 71%
  - LLN ~ 60%

Parameter	Value	Reference Value	% Predicted	Standard Residual
FEV1 (L)	2.16	2.61	83	**-0.89**
FVC (L)	3.62	3.62	100	**-0.01**
FEV1 Ratio	60	71	84	**-1.63**

FEV1 Ratio

- 18 year old female, height 1.78m
- Reference FEV1 Ratio 86%
  - LLN 75%

Parameter	Value	Reference Value	% Predicted	Standard Residual
FEV1 (L)	2.73	3.98	69	-3.29
FVC (L)	4.53	4.53	100	0.00
FEV1 Ratio	60	86	70	-3.90

Severity Interpretation Using FEV1 Ratio

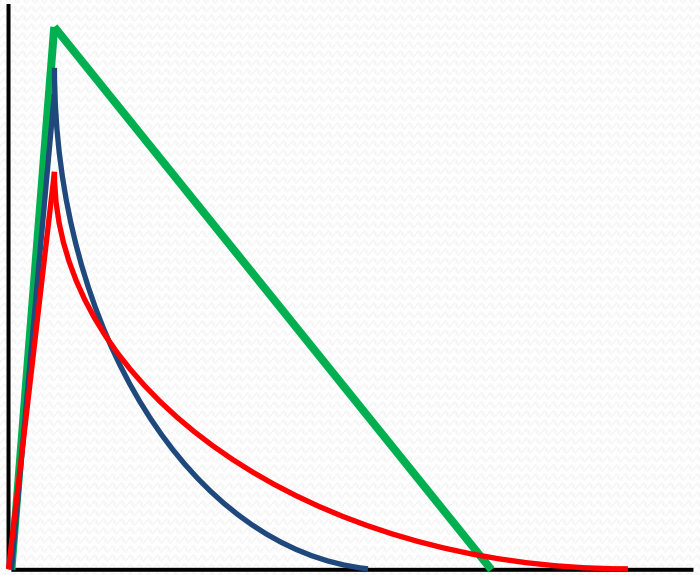
SR = $\frac{\text{Measured} - \text{Predicted}}{\text{Residual Standard Deviation (7.17)}}$

- FEV1 2.57 (69% pred)
- FVC 3.73 (81% pred)
- Ratio 69% (pred is 78%)
- Moderate obstruction

$\frac{69 - 78}{7.17} = -1.25$ (Normal)

- FEV1 3.00 (81% pred)
- FVC 6.22 (135% pred)
- **Ratio 48% (pred is 78%)**
- Mild Obstruction

$\frac{48 - 78}{7.17} =$ **- 4.18 (Severe Obstruction)**

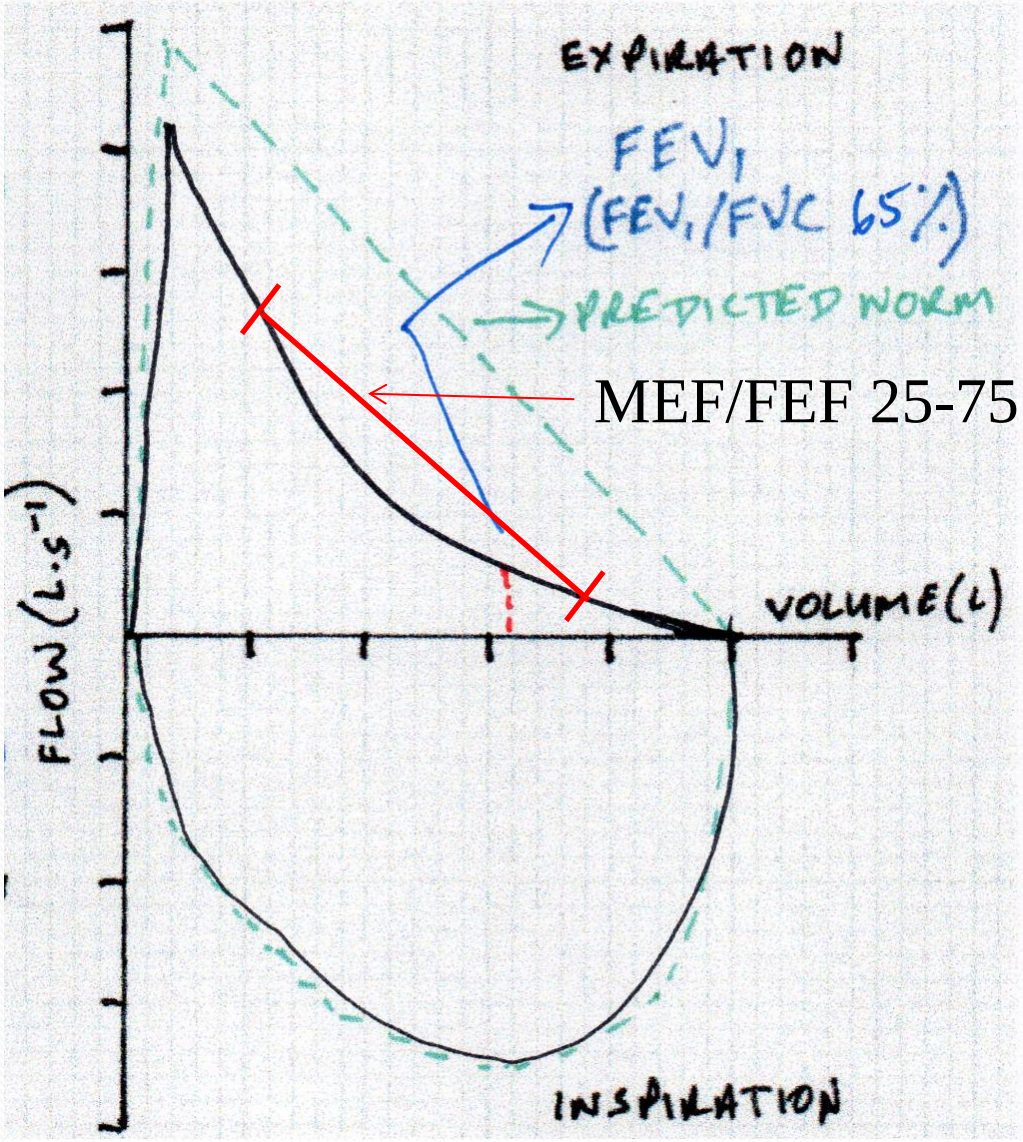


Spirometry Interpretation

Spirometry	FVC	FEV_1 Ratio
Normal	> LLN (⇔)	> LLN (⇔)
Obstructive	> LLN (⇔)	**< LLN / SR (🡻)**
? Restrictive	< LLN (🡻)	> LLN (⇔)
Combined	< LLN (🡻)	< LLN (🡻)

Mid Expiratory Flows

- Smaller airway function
- Different units
- Wider variation
- Interpret cautiously



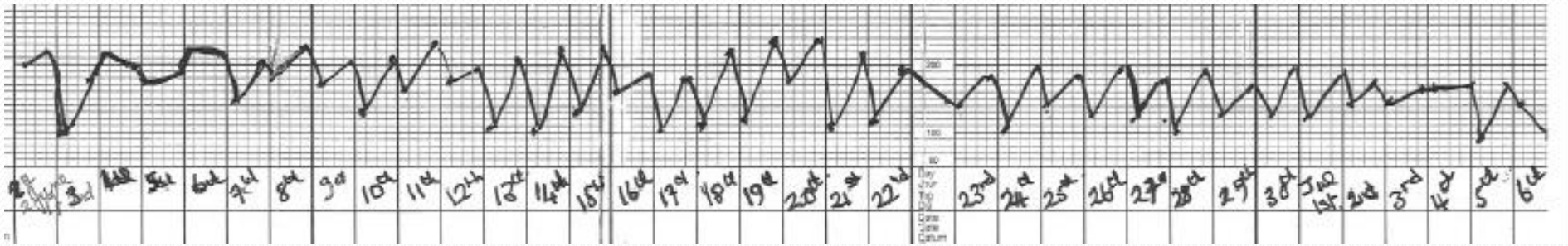
PEF

- Variability and diurnal variation
- Variability > 10% suggestive of abnormality and suboptimal control with BD measurements

$$\frac{\text{Highest PEF} - \text{Lowest PEF}}{\text{Mean of highest+ Lowest PEF}} \times 100$$

- Visual diurnal variation

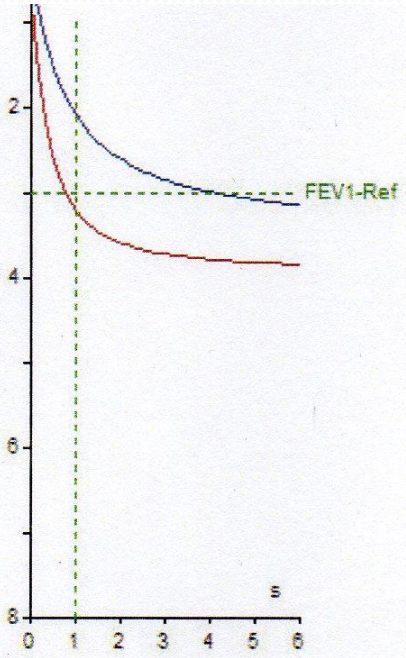
PEF diurnal variation

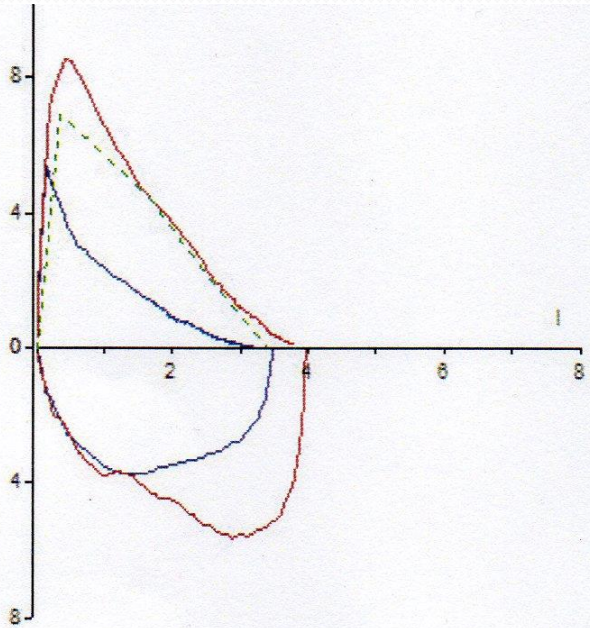


Reversibility

- Spirometry and change in FEV1 still considered gold standard for assessing reversibility
- 200 ml AND 12% Increase in FEV1

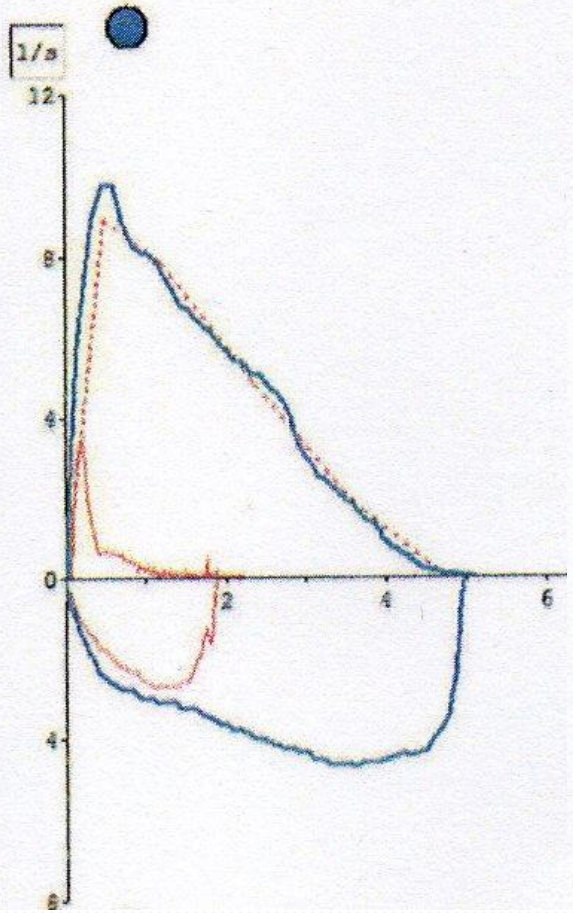
Reversibility





time			14:51		15:24		
medicament							
parameter	unit	pred.	pre	%pred.	post	%pred.	post%pre
FVC	l	3.46	3.28	95	3.93	114	20
FEV1	l	3.01	2.08	69	3.23	107	55
FEV1/VC	%		60		82		37
FEV1/FVC	%		63		82		29
PEF	l/min	411	320	78	511	124	60
MEF75	l/s	6.03	2.69	44	6.67	110	148
MEF50	l/s	5.23	1.76	34	4.56	87	158
MEF25	l/s	2.05	0.54	26	1.33	65	146
MEF25-75	l/min	235	74	31	190	81	157

Reversibility

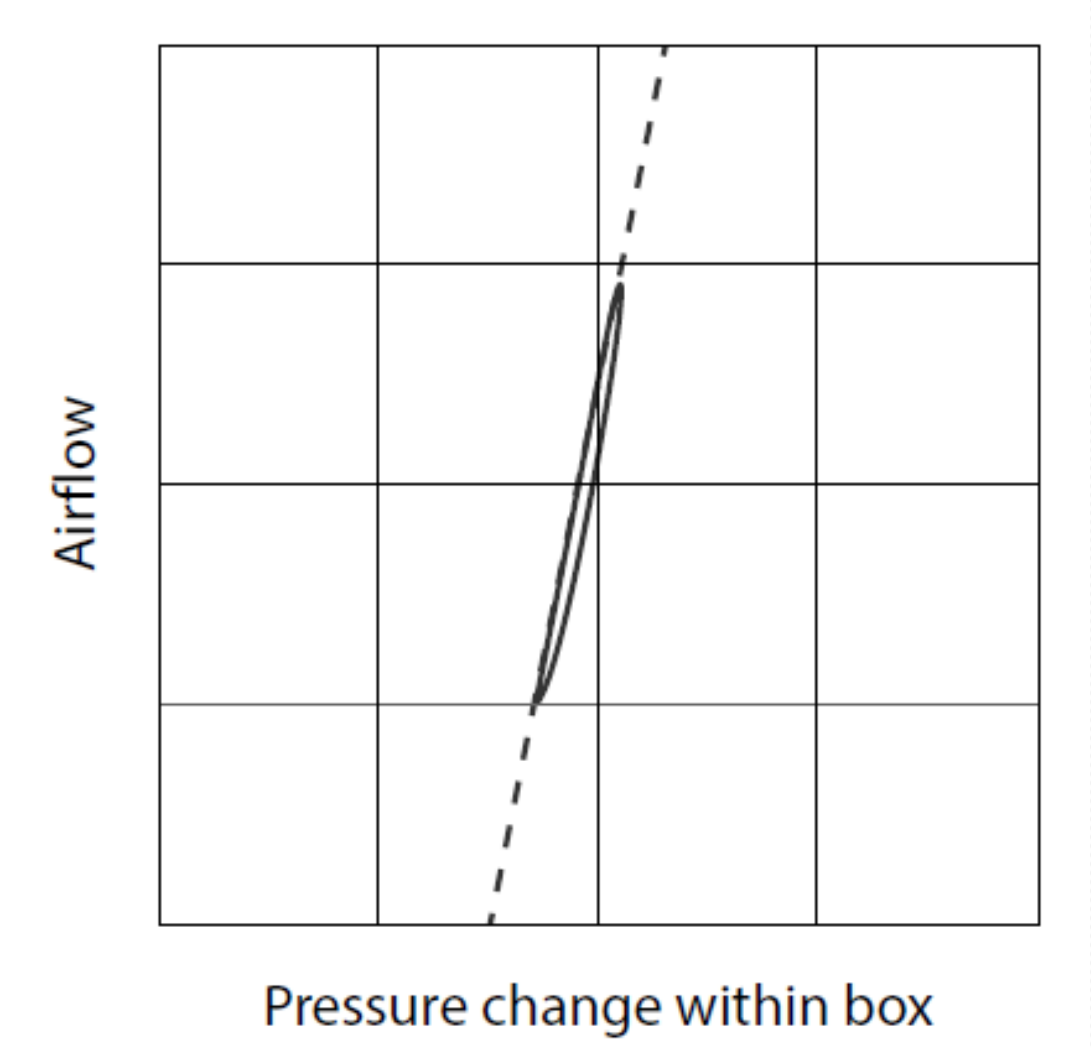


Parameter	Reference 11.01.2018	%Ref	Effort 1	%Ref
VC	3.17	64%	4.41	89%
TV	0.56		0.59	
FEV1	0.90	24%	3.98	106%
FVCex	2.20	40%	5.08	107%
FEV1/FVC	41		78	
FEV1/IVC	28		90	
PEF	211	39%	589	109%
MEF25	7	8%	84	71%
MEF50	10	4%	288	99%
MEF75	40	9%	445	94%
	0.08		0.08	
	11.4		10.1	

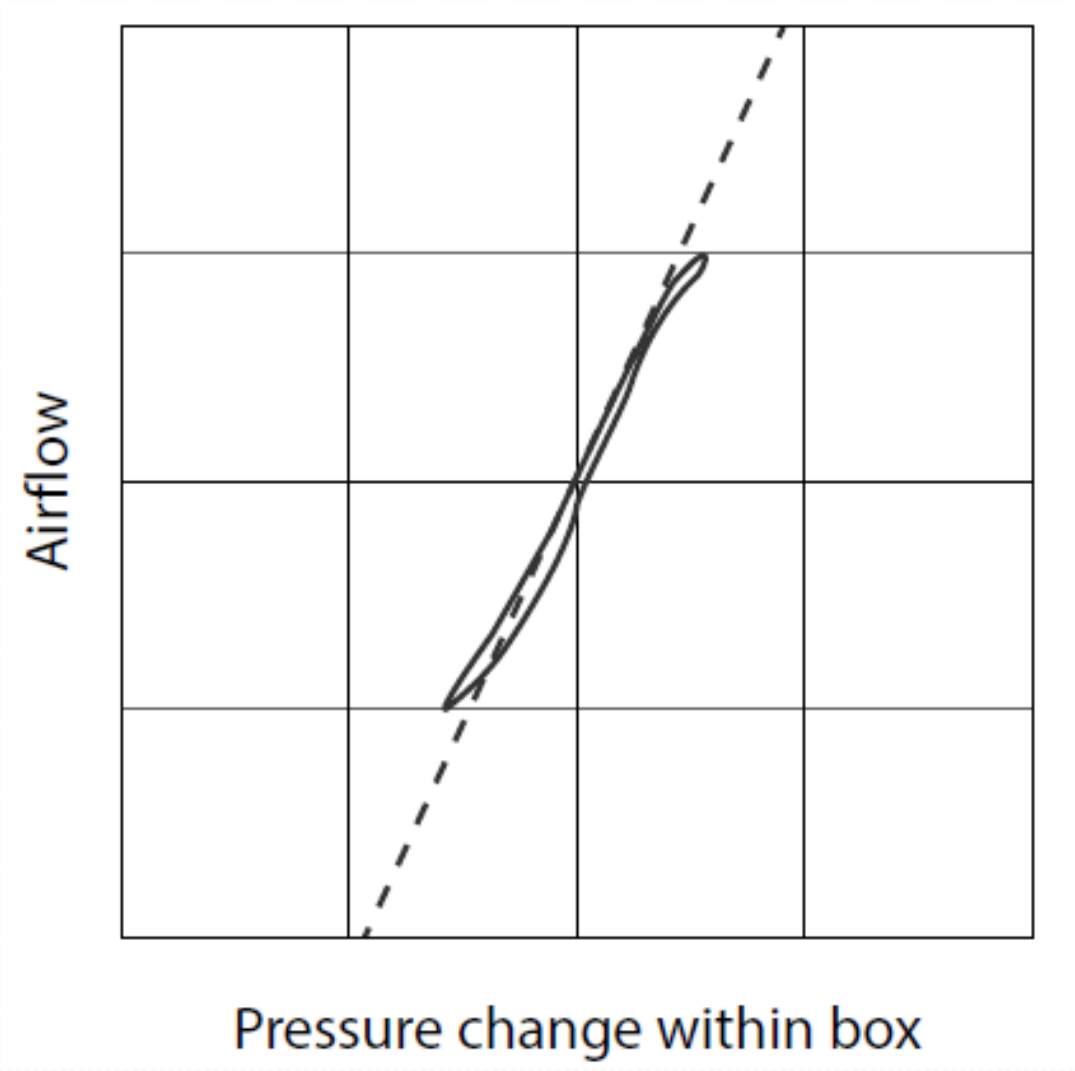
Airway Resistance

- One of few indices where value greater than average suggests pathology
- May suggest airway disease with normal spirometry

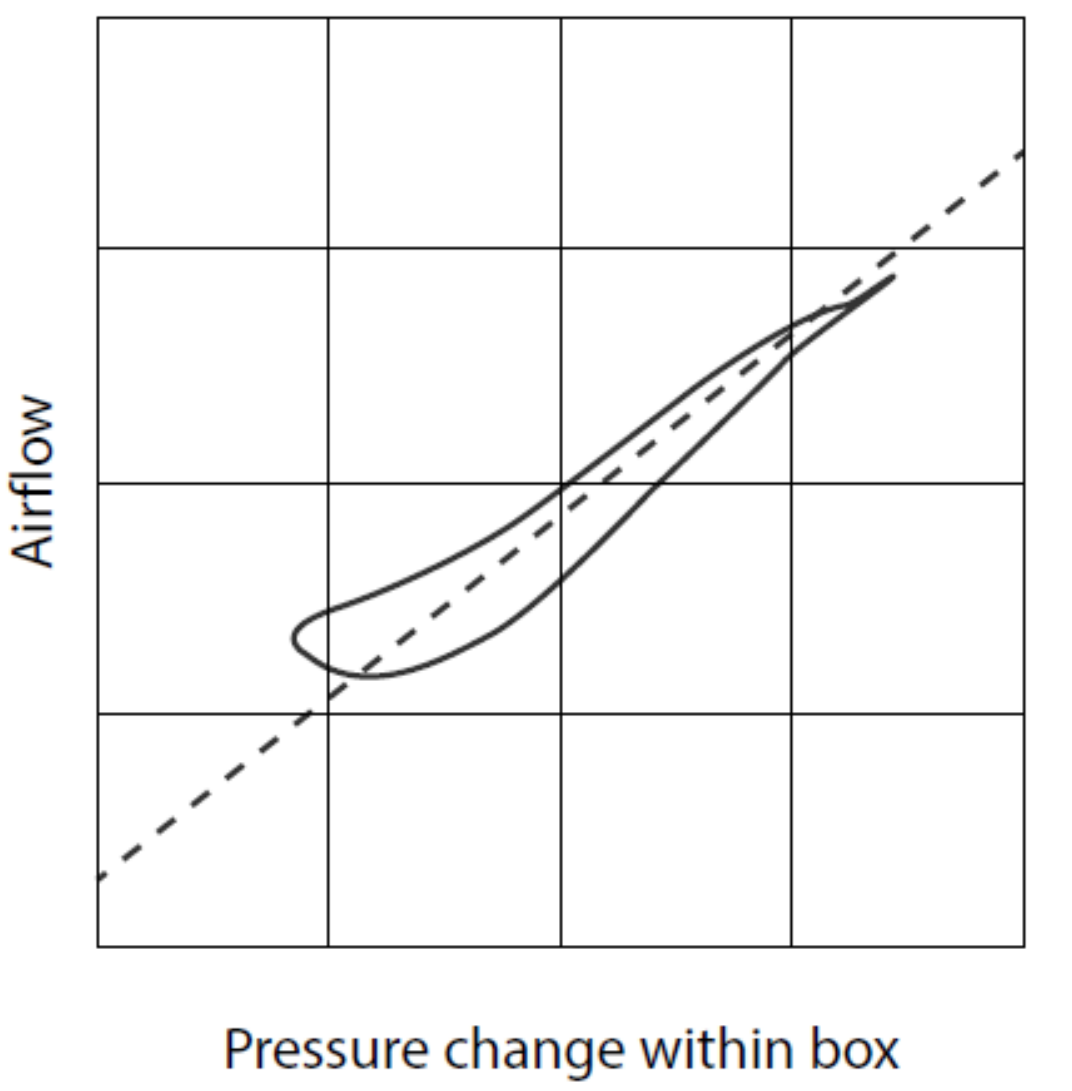
Airway Resistance



Airway Resistance

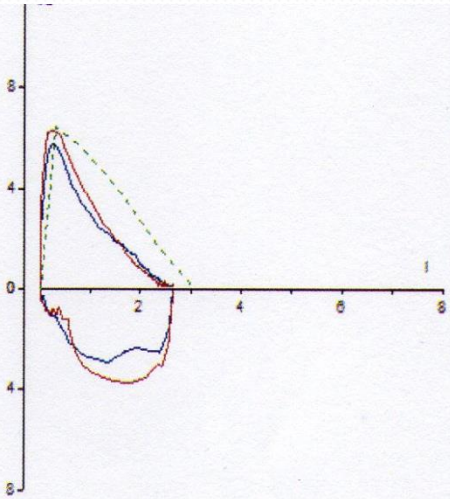


Airway Resistance



Airway Resistance

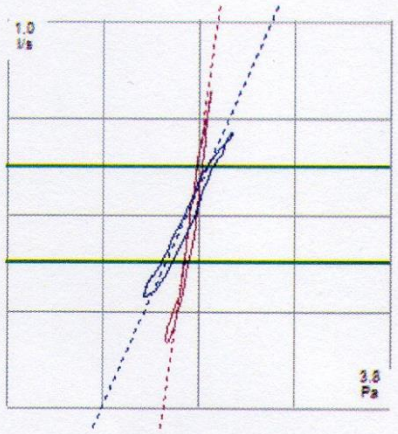
PARAMETER	UNIT	PRED.	PRE	%PRED.	SR	POST	%PRED.	SR	POST% PRE
FEV1	l	2.65	2.21	83	-1.16	2.18	82	-1.24	-1
FVCex	l	3.08	2.81	91	-0.63	2.68	87	-0.92	-4
FEV1/FVC	%		79			81			3
VC	l	3.05	2.67	88	-0.89	2.70	89	-0.83	1
FEV1/IVC	%		83			81			-2
PEF	l/min	383	345	90	-0.70	376	98	-0.14	9
FIV1	l	2.73	2.44	89		2.48	91		2
FVCin	l	3.05	2.65	87	-0.96	2.66	87	-0.91	1
PIF	l/min	258	175	68	-1.51	223	86	-0.64	28



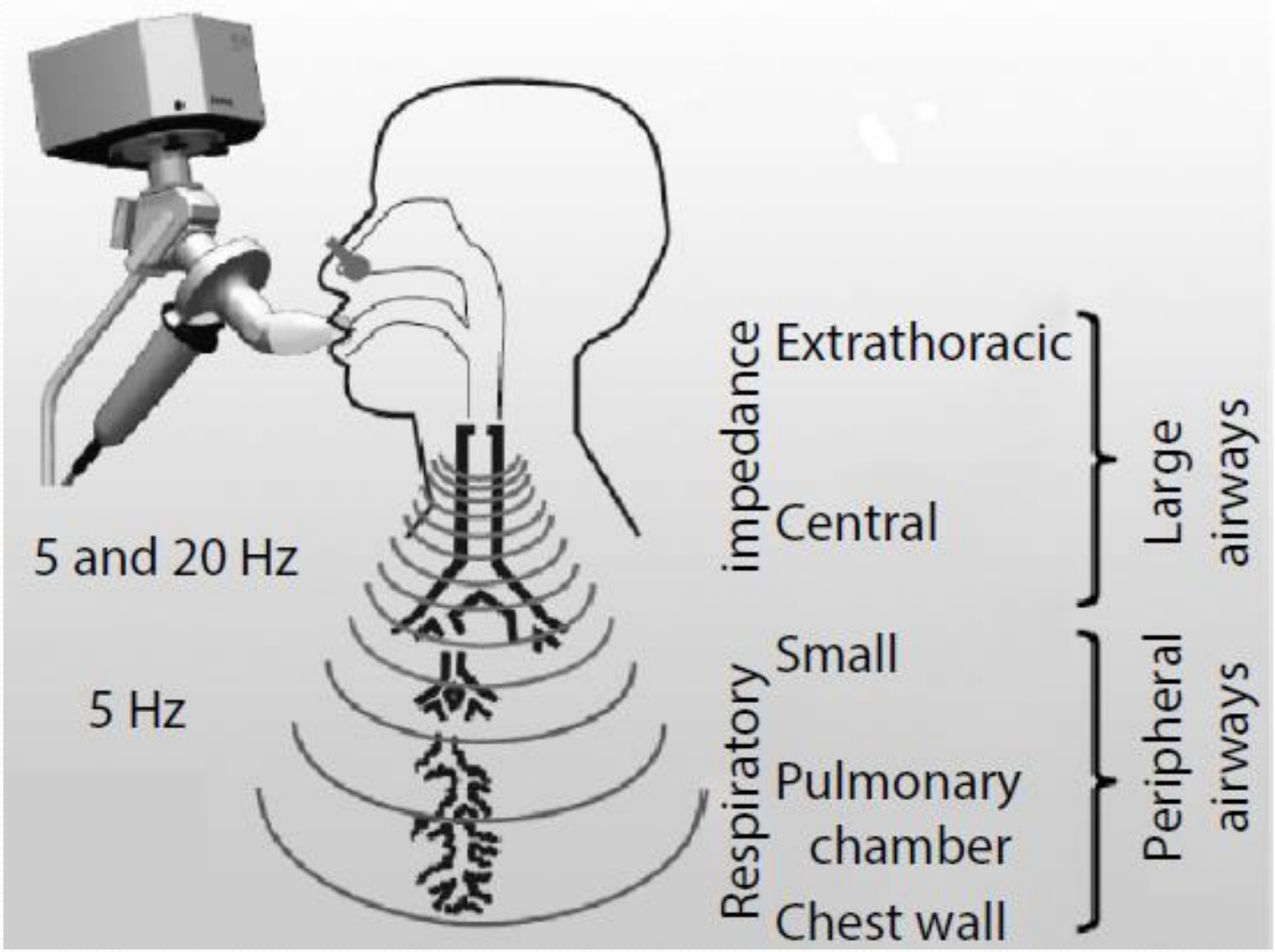
Body Plethysmography

LUNG VOLUMES AND SUBDIVISIONS

PARAMETER	UNIT	PRED.	PRE	%PRED.	SR	POST	%PRED.	SR	POST% PRE
TLC	l	4.57	3.75	82	-1.38	3.93	86	-1.08	5
RV	l	1.45	0.94	65	-1.45	1.18	81	-0.78	25
VC	l	3.05	2.67	88	-0.89	2.70	89	-0.83	1
TGV	l	2.55	1.65	65	-1.80	1.99	78	-1.13	20
TGV/TLC	%	51	44	86	-0.72	51	99	-0.05	15
RV/TLC	%	32	25	79	-1.16	30	94	-0.33	19
RESISTANCE									
RAWtot	kPa/(l/s)	0.30	0.95	318		0.25	82		-74
sRAWtot	kPa*s	0.77	1.58	206		0.49	64		-69



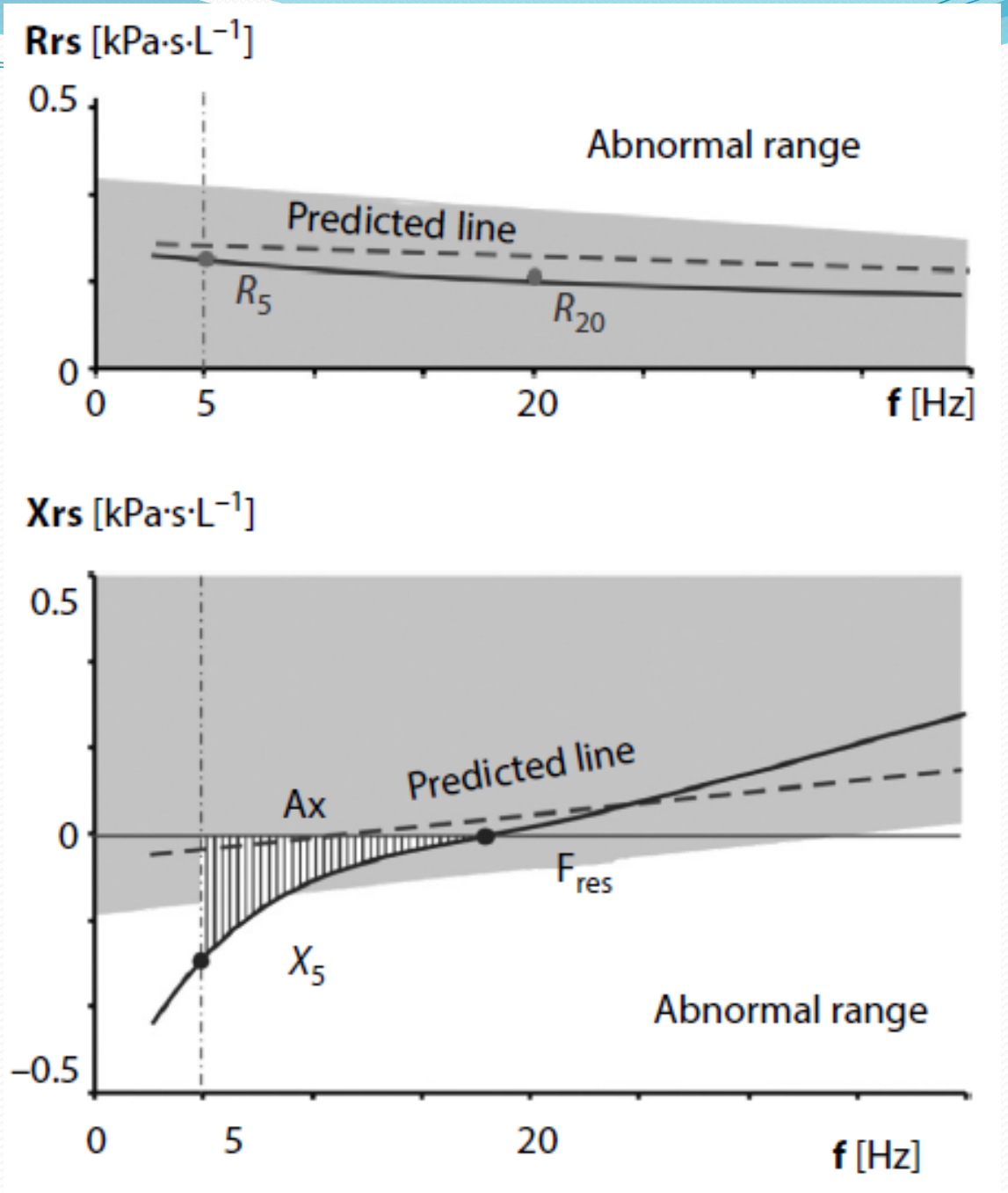
Oscillometry



Oscillometry

Abbreviation	Parameter
R_5	Resistance (5 Hz)
R_{20}	Resistance (20 Hz)
$R_5–R_{20}$	Resistance (5–20 Hz)
X_5	Reactance (5 Hz)
Ax	Reactance area
F_{res}	Resonant frequency

Oscillometry



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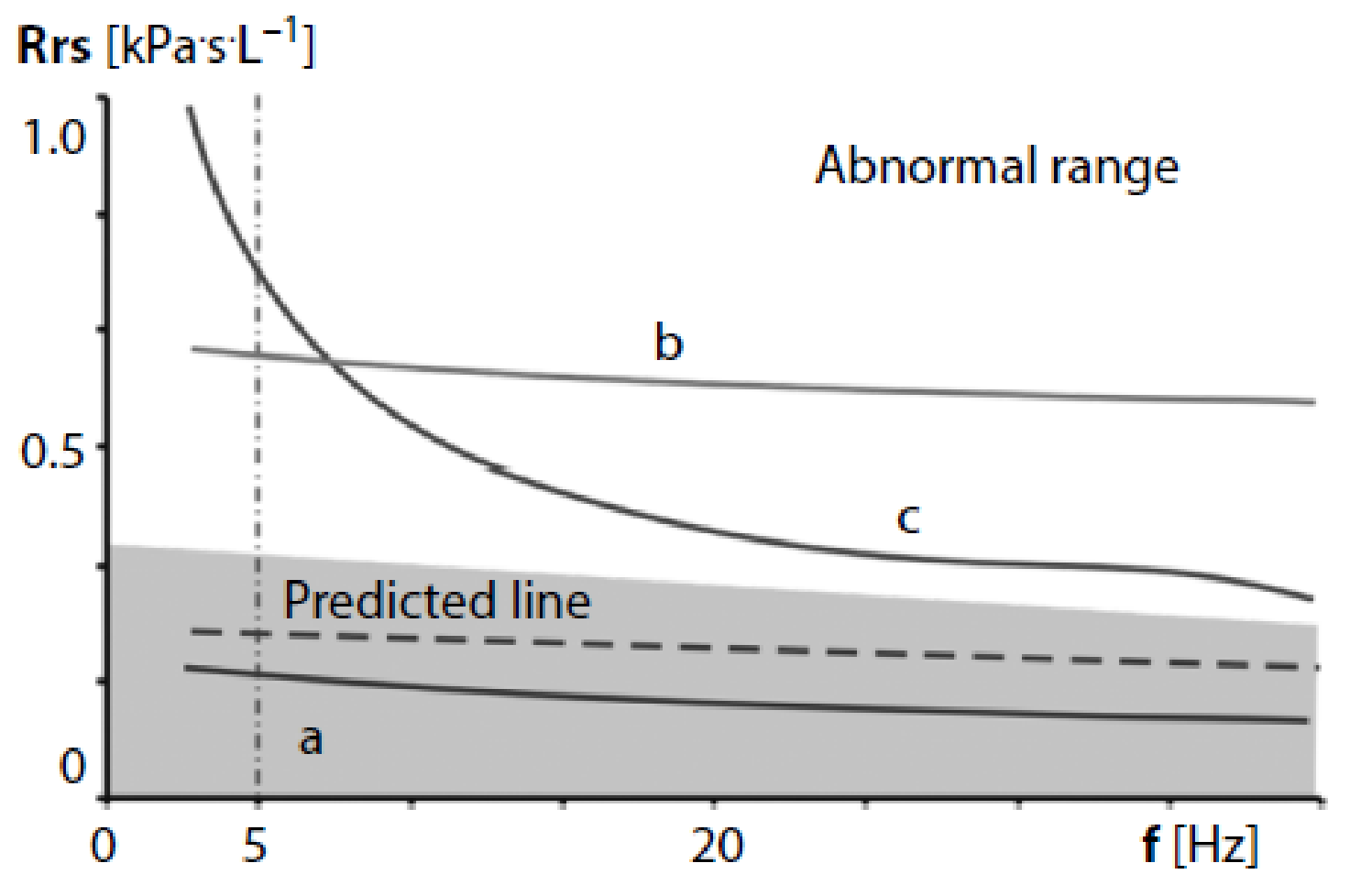

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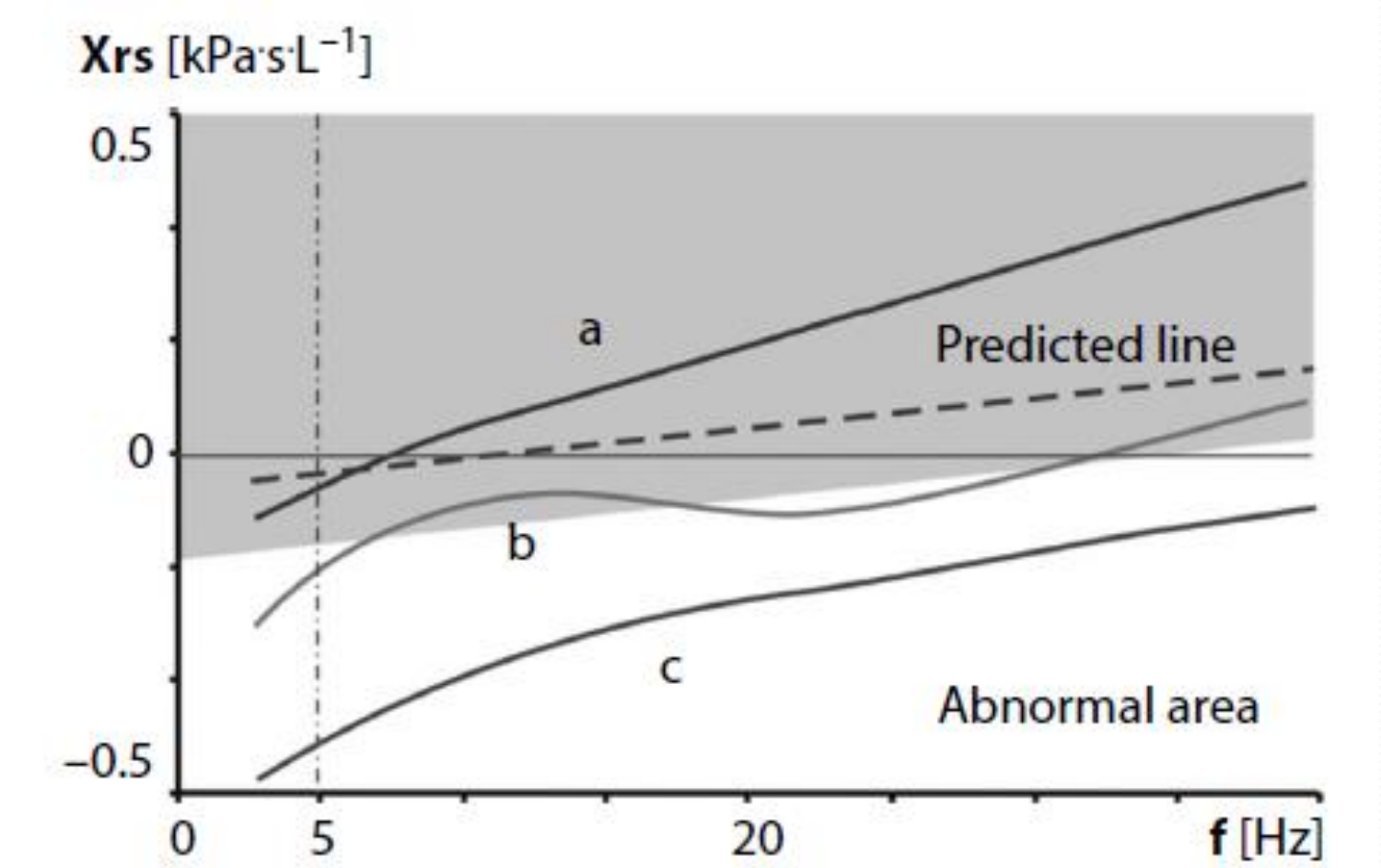
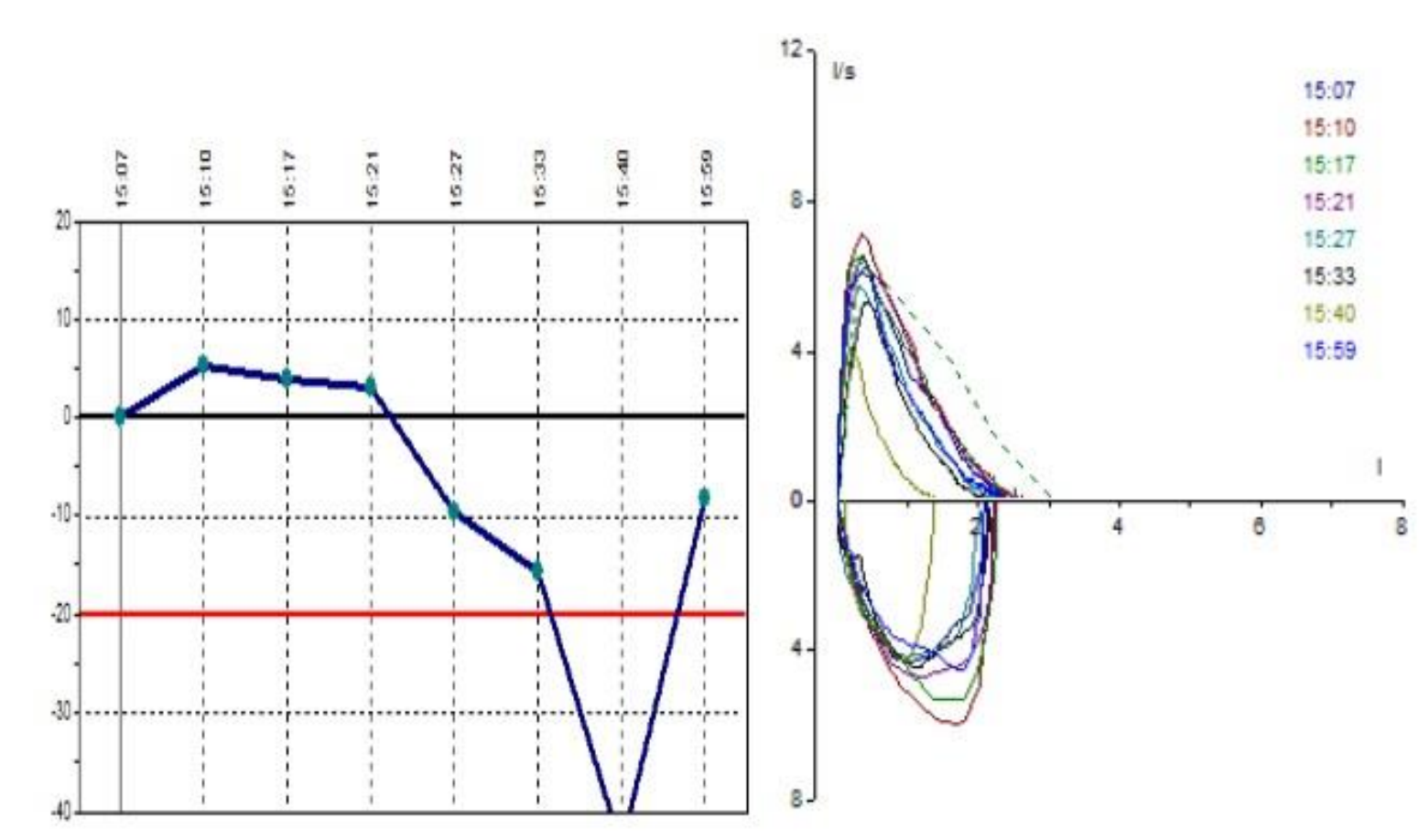


Other tests

- Challenge test
- Lung Clearance Index (LCI)
  - Time to washout inert gas
  - Index of obstruction
  - ? Different patterns with different airway involvement
- Capnography
  - Altered waveforms in normal, asthma and COPD

Challenge Test

- PC/PD20



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Conclusions

- Assessment of airway function and changes over short periods important for confirmation of asthma diagnosis
- Accurate assessment depends on understanding normal values, expressions of normality and interpretative strategies
- Spirometry is still gold standard for assessing changes in airway function
- Tidal breathing assessment becoming more clinically available with complementary utility.