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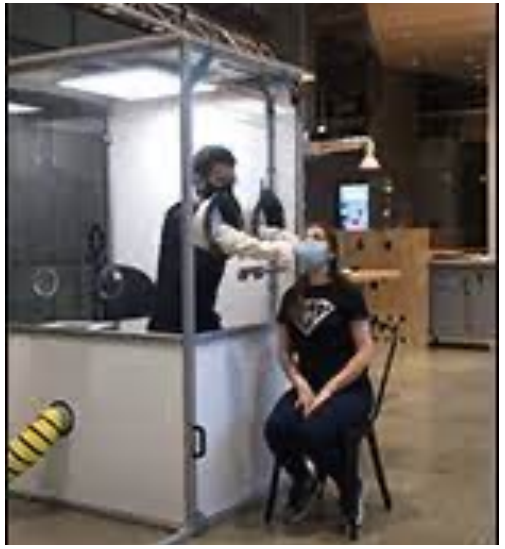
Getting back to spirometry

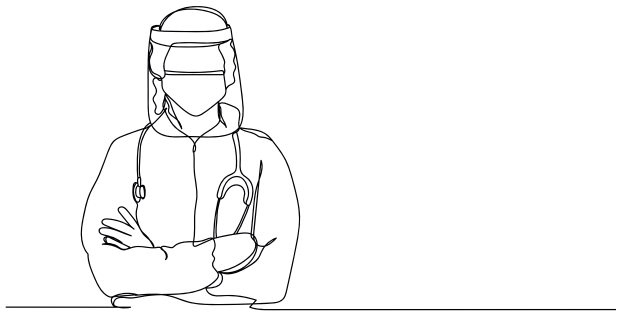
The missing link in the diagnostic pathway

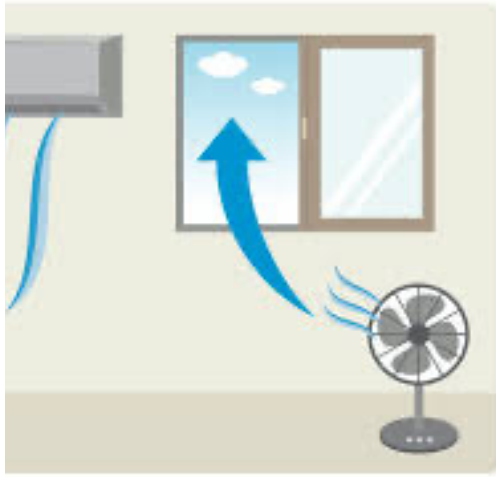



Reinstating spirometry safety
But – where do we start









What do the guidelines advice?

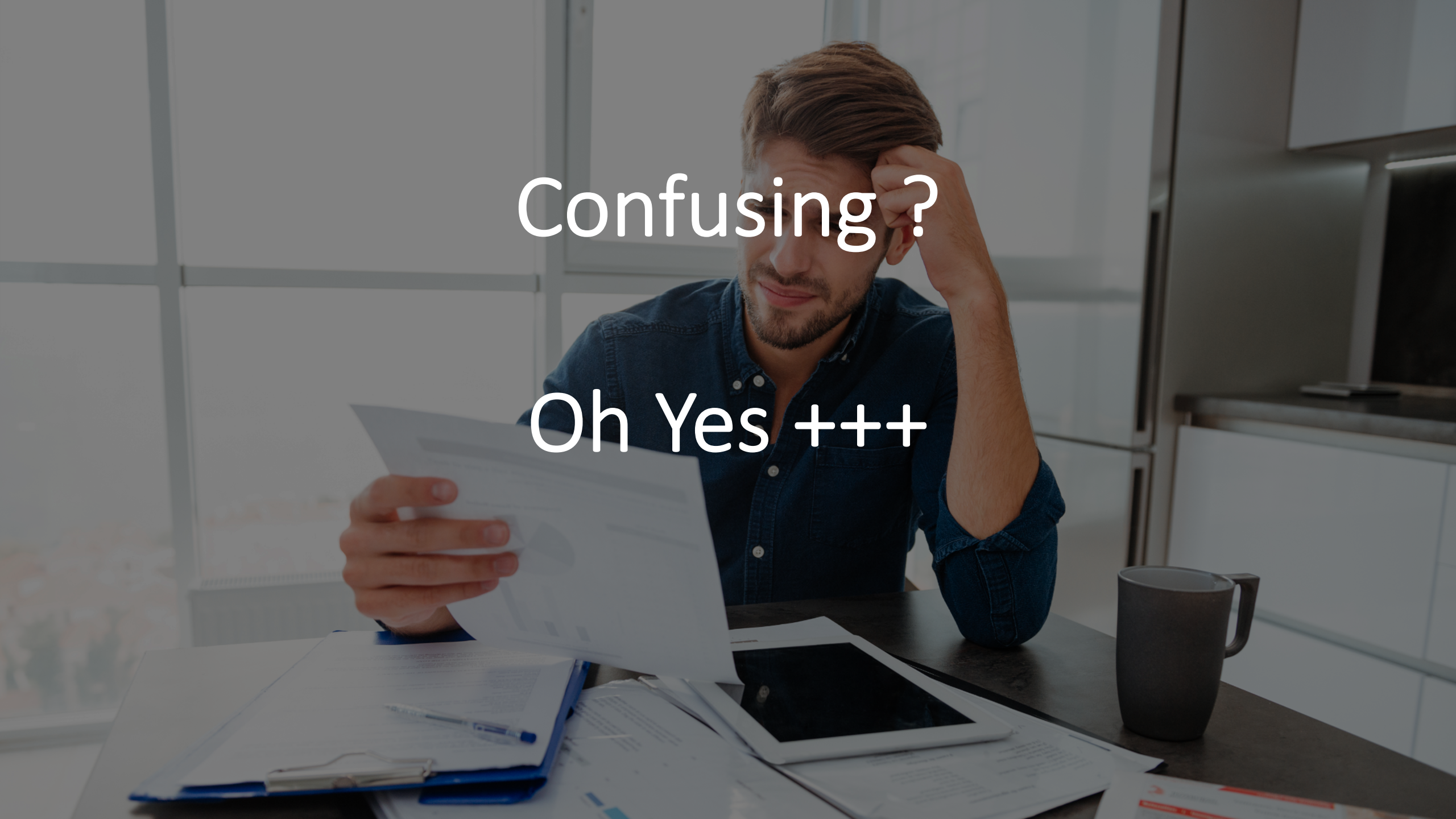

Confusing ?
Oh Yes +++

Table 1. Approach to assessing risks of undertaking Respiratory Function Testing ARTP 2020

Modified to demonstrate how the aerosol generating potential of Spirometric testing changed during the course of the pandemic



Risk	Low	Moderate	High
Procedure	Low exhalatory flow on filter system (e.g. FeNO), gas transfer measurement	Spirometry (acute and community Trusts). Full respiratory function testing (mouth pressures, lung volumes, etc.)	Procedures potential coughing provocation testing), and those causing increased levels of patient ventilation (e.g. CPET)

Infection control measures – As per ARTP 2022

Spirometry is not considered to be an aerosol generating procedure (AGP).

However, spirometry-associated cough has the potential to generate aerosol droplets and therefore necessitating a mitigation strategy which may include that :

- All tests must be performed using a single use antibacterial antiviral filter.
- The spirometer must be cleaned between patients per manufacturer's COVID- specific instructions. As a minimum this should involve cleaning the outer casing of the transducer and the outer part of the spirometer itself with alcohol wipes.
- Operators will need Personal Protective Equipment (PPE) consisting of gloves, apron, visor and Type IIR (surgical) mask.
- A Perspex screen between patient and operator offers an additional physical barrier for protection.
- If available, use a room with mechanical air circulation or ventilate as able (e.g. open windows), Ideally this should be in the region of 6 room air changes per hour.
- Other options that may be considered depending on the local situation include a drive through service or virtual spirometry

(ARTP 28th April 2021)

https://www.artp.org.uk/News/risk-minimisation-in-spirometry-re-start-task-and-finish-group-document - Last Accessed 26th April 2022

SO effectively 

IS . . .

- **We all** need to robustly ‘Risk Assess’ our own clinical space
- **We all** need to robustly assess the skill level of the practitioners
- **We all** need to take personal professional responsibility moving forward

Preparing your clinical space





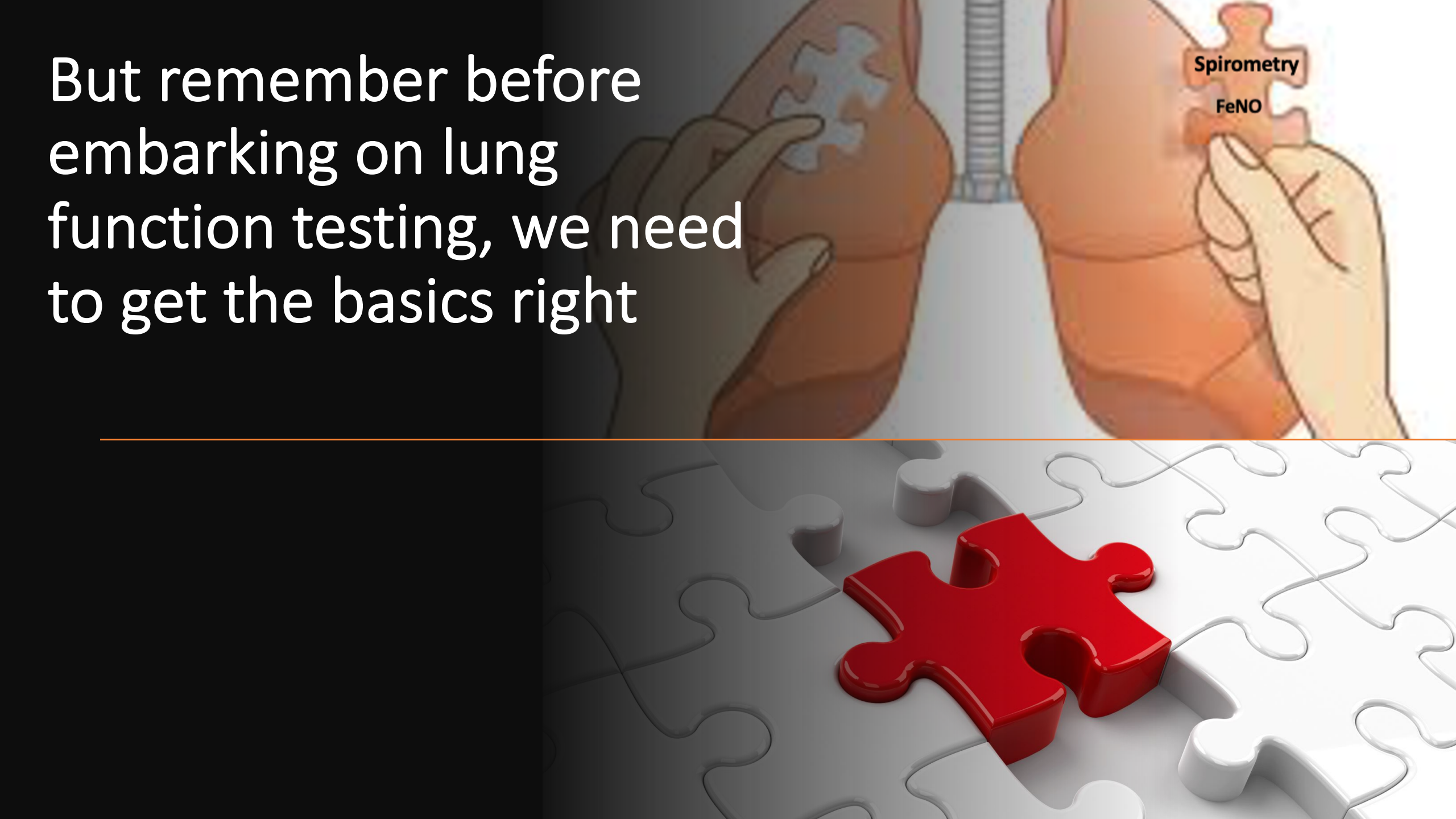
Ensuring a safe space for you and your patient





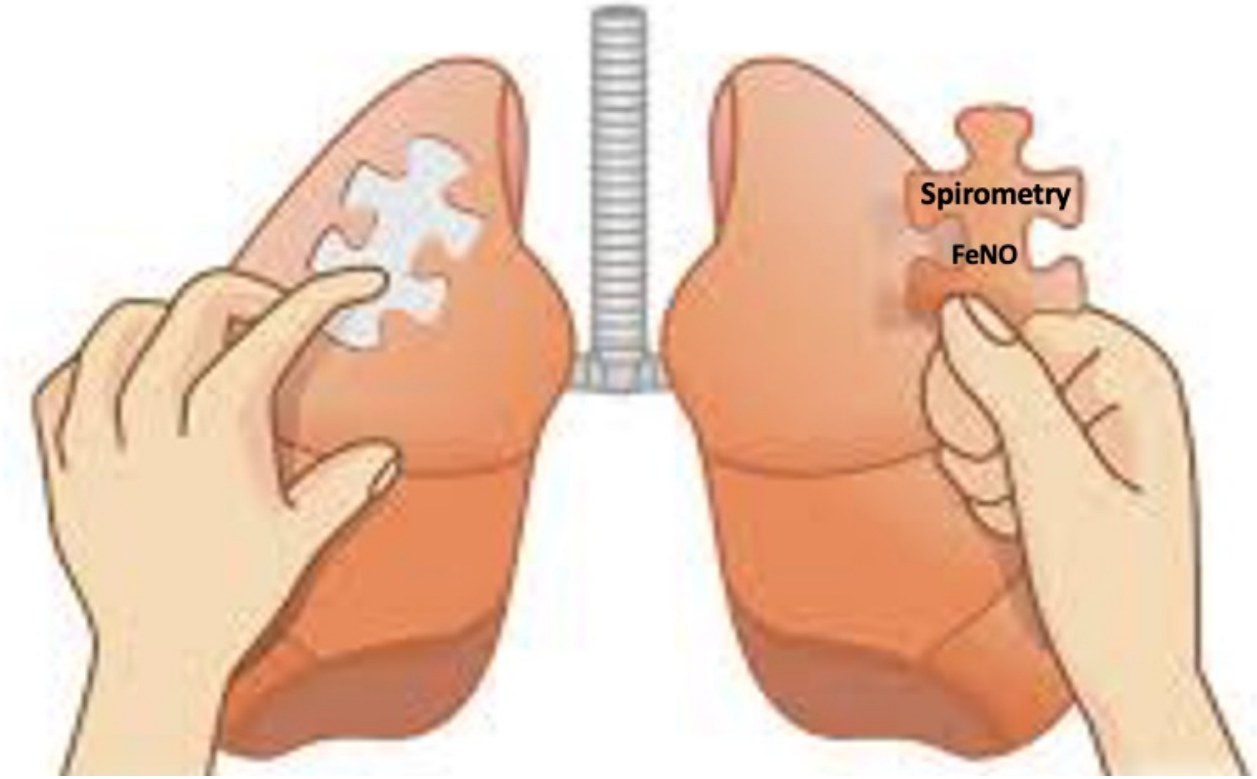
It doesn't have to cost the earth

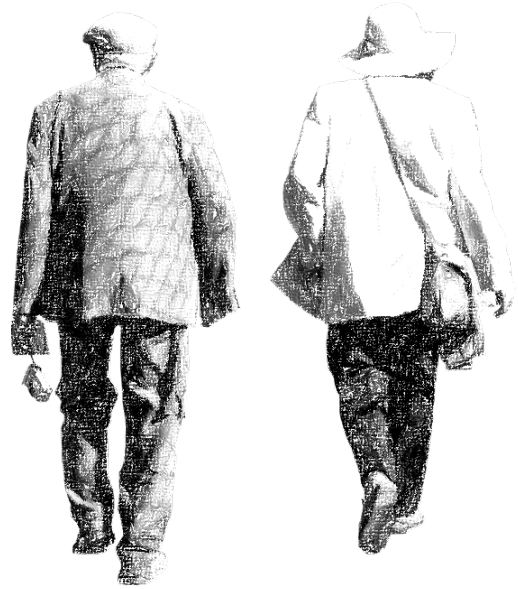
But remember before embarking on lung function testing, we need to get the basics right



Back to basics

Every Patient is a ‘Jigsaw’ in a box





Reference – Barrett McGrath EMS Ltd

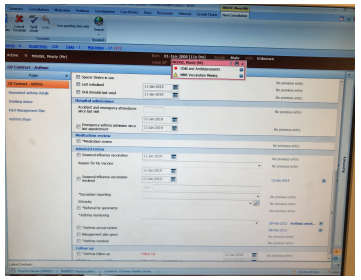
Potential respiratory conditions patients may present with

- **COVID-19**
- Bacterial lung infection
- Pneumonia
- Asthma
- COPD
- Bronchitis- chronic or acute – non-obstructive
- Emphysema – non-obstructive
- Cough variant asthma
- Idiopathic chronic cough
- Bronchiolitis
- Inhaled foreign body
- Lung cancer
- Sarcoidosis
- Sleep apnoea
- Type 2 respiratory failure
- Interstitial Lung Disease (ILD)
- CCF
- Plus, many others



We need to be able to determine the most likely diagnosis by building the jigsaw picture

Optimally utilize the many resources available to support our clinical consultations





















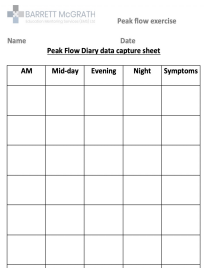
























FBP – looking for

1. Eosinophils
2. Hemoglobin
3. Neutrophils
4. Macrophages

1. CRP
2. Pro BNP

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We can effectively use so many via a virtual platform if necessary























Preparation is key to success







Re-engage with lung function testing in a safe, well-informed and competent manner today









Lung Function Testing – an objective test that helps to diagnose

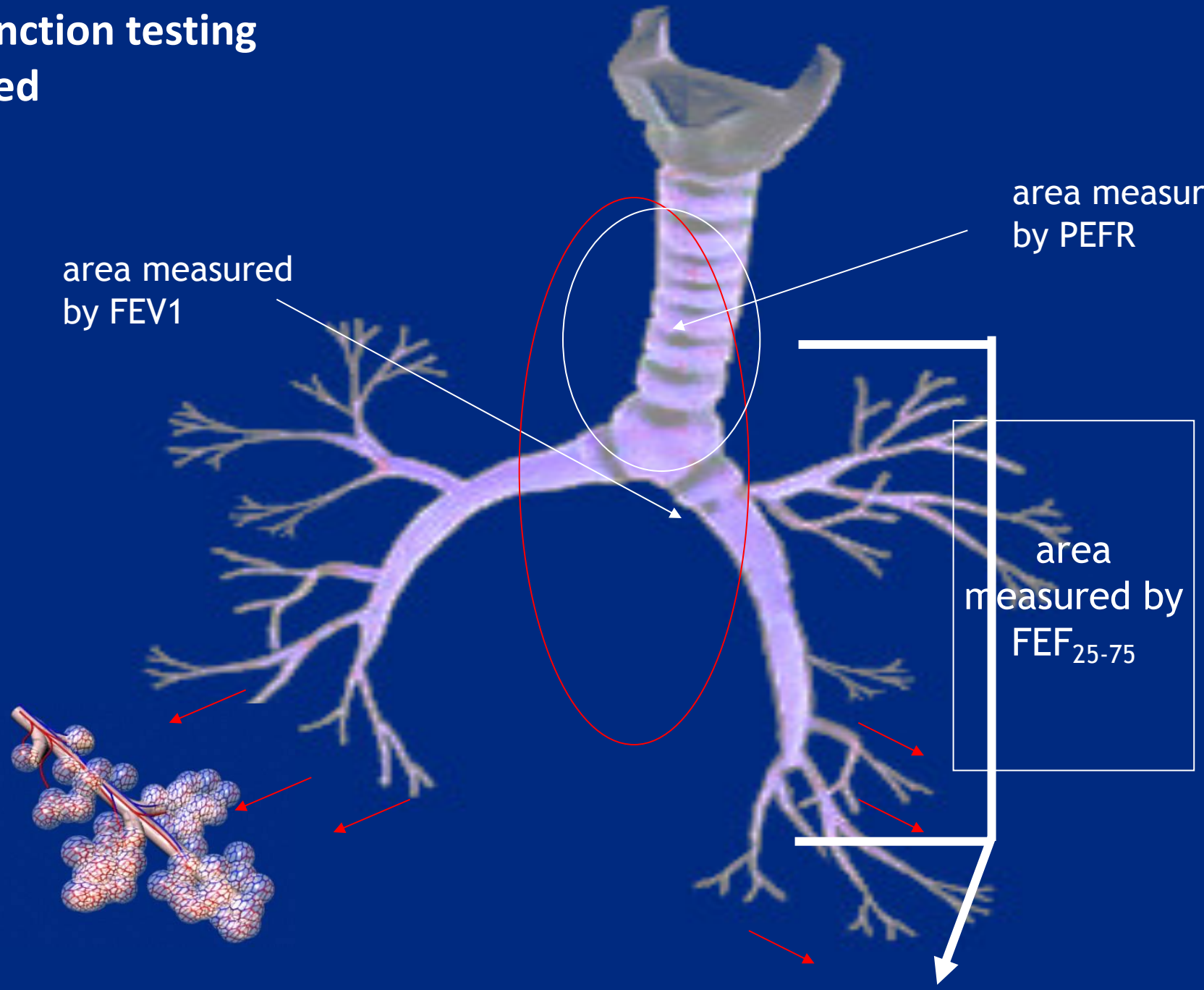
Spirometry

- *Screening*
- *Base*
- *Reversibility*
- *Post therapy*

Peak flows

- *One off opportunistic*
- *Serial peak flows*
- *Exercise peak flow measures*
- *Reversibility testing*

Lung function testing explained



Never underestimate the power of the “humble” Peak Flow – home monitoring for asthma and COPD



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Peak flow exercise

Name Date

Peak Flow Diary data capture sheet

AM	Mid-day	Evening	Night	Symptoms

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Peak flow exercise

Name Date

Result sheet

Highest Peak flow	Lowest Peak flow	Litres/min	%
500	400	100	20%

READ CODE 66YY PF , PF monitoring 66Yx, Number of days PF below 80% 66Yc

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Peak flow exercise

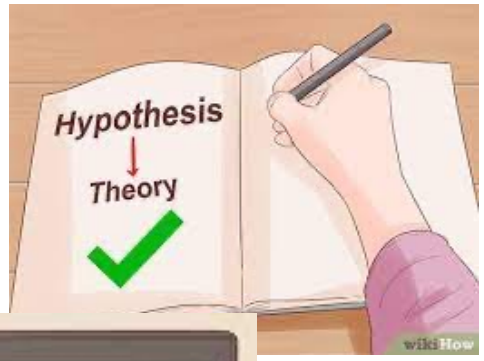
Name Joe **Date** 7th October 2020

Peak Flow Diary data capture sheet

AM	Mid-day	Evening	Night	Symptoms
380	420	500	460	Coughing in the morning
270	400	490	420	Tight in the morning
300	290	500		Took a few puffs of Salbutamol
280	250	460	490	Was SOB walking
230	250	500	480	Took 2 puffs of Salbutlamol

Form your theory …

Reflecting on the evidence collated …





- Does it look like COPD or asthma or other
- What are the patient's risk factors?
- Are the symptoms and presentation suggestive of COPD or asthma
- **If yes, then …**
- Look for identifiable treatable traits
- Look for biomarkers – neutrophils, eosinophils CRP etc
- Conduct a holistic assessment
- **Code 1J71 (suspected COPD) in conjunction with 8HRC (referral for spirometry) book spirometry when available**
- **Code 1J70 (suspected Asthma) – serial peak flow – then a 4-week trial of ICS**
- **Then treat in line with NICE 2020 or GOLD 2021**

Manage the COPD treatable traits –

Quality of Life (QoL) measured by the COPD assessment Test (CAT) and code result against 38Dg
Dyspnoea – BORG score (0-10) resting and OE –
Measure spo2 at rest and OE (leave in-situ for at least 1 minute before reading)
Record pulse – Rhythm & rate
Note mMRC score

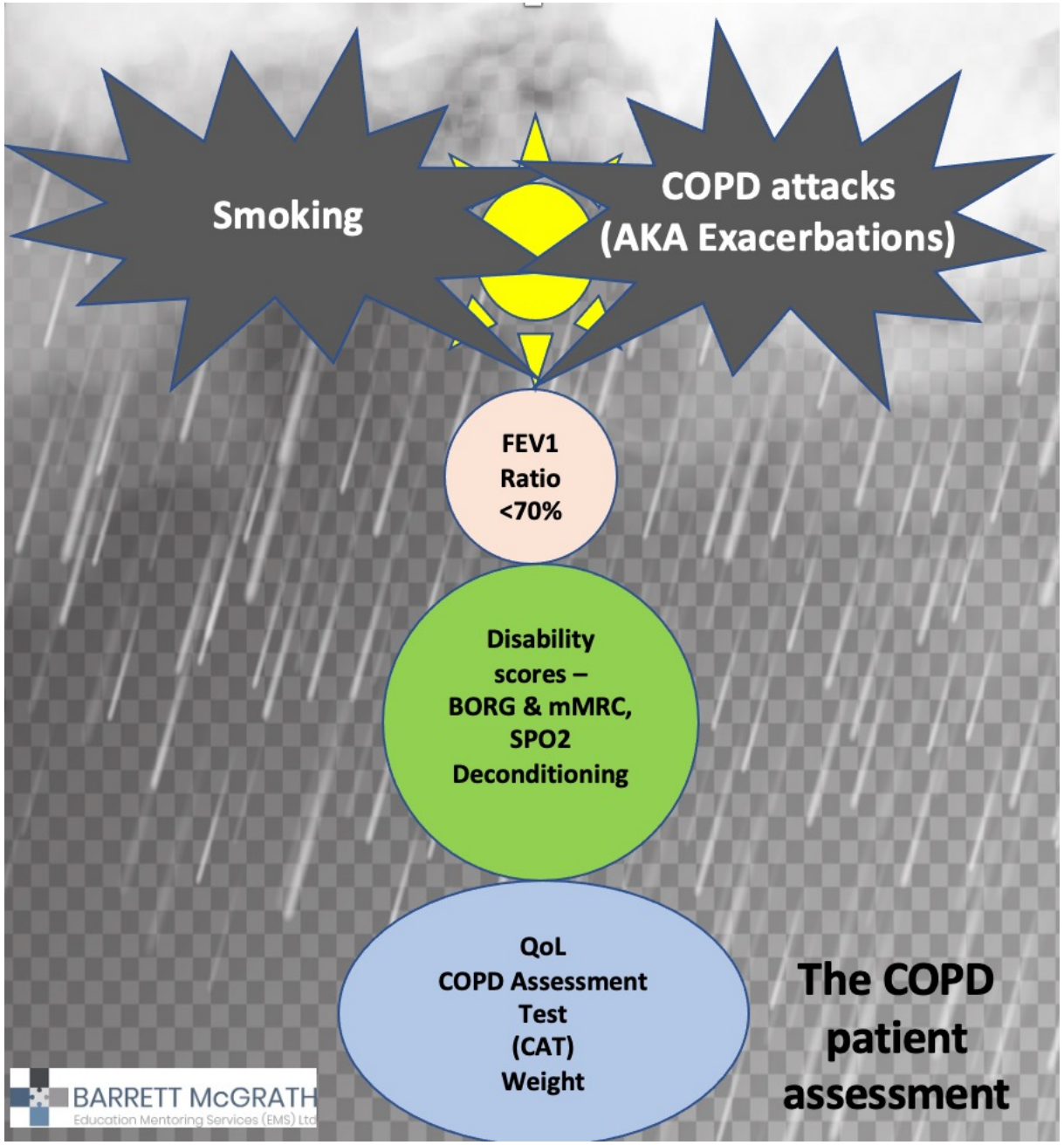
Consider biomarkers –

Eosinophils
Hemoglobin
Neutrophils

Manage COPD attacks (exacerbations)

Using 66Yf code the number of COPD Attacks and free text the severity (mild, moderate or severe)

- *Manage patient as per GOLD or NICE*
- *Teach and assess inhaler technique*
- *Collaboratively develop a personal action plan (PAP)*
- *Where appropriate provide education and self management bespoke to patient requirements*





Education & Upskilling in Spirometric testing will help mitigate against poor or inconsistent quality tests and inaccurate interpretation

The ARTP, PCRS and Respiratory service framework for NI recommends:

- Anyone undertaking spirometry should have completed a recognised spirometry course and be competent in performing spirometry and interpretating the results
- Each qualified practitioner should subsequently undertake a three yearly update



Best Advice

1. Complete one of the recognised spirometry courses – if you have not yet done so
2. Attend a three yearly update course prior to restarting spirometry

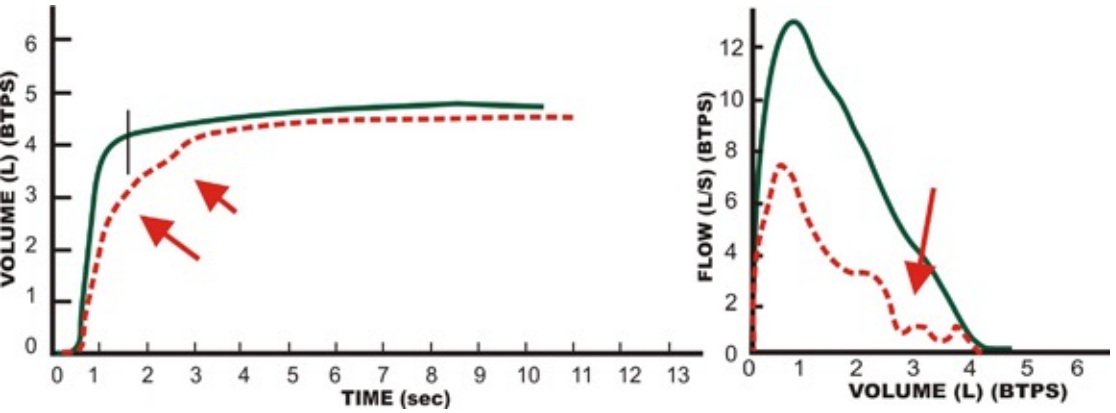
Spirometric testing is NOT just a ‘trivial’ examination – but rather a critical, gold standard diagnostic test

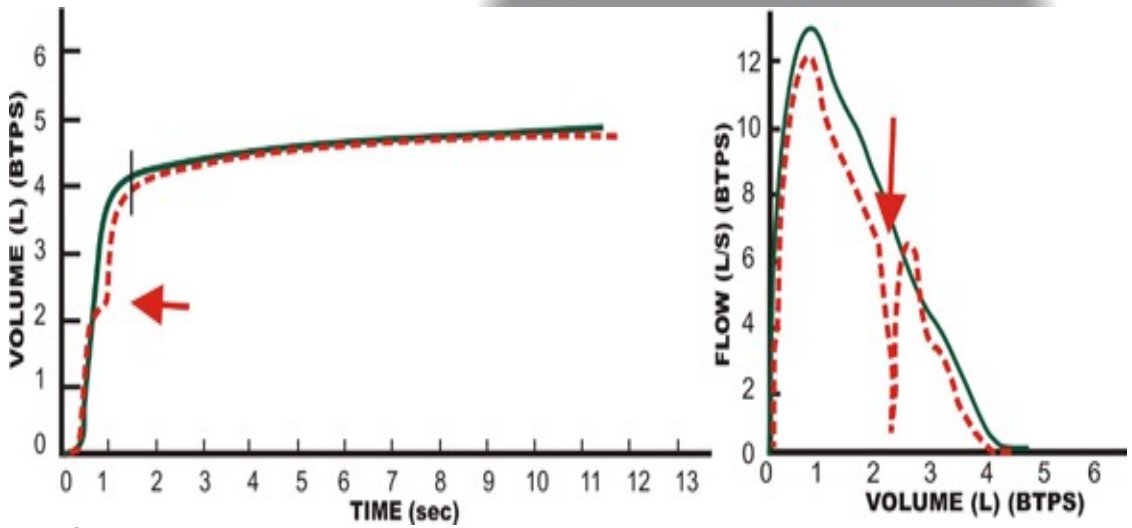
And **Rubbish in = Rubbish out**



=







Poor spirometry unworthy of interpretation

Spirometry



Spirometry measures the volume of gas that can be moved out (or in some cases in) of the air-conducting passages and the maximum speed at which this gas can be forcibly expelled from a position of full inspiration to full expiration in one steady manoeuvre.

<u>Measuring:</u>

Volume in Litres

+

Speed in Litres/Sec

Spirometry can help ….











- To identify an abnormality
- To quantify the severity of the obstruction in COPD
- To locate the main sites of dysfunction
- To monitor response to treatment
- To monitor the progression of a respiratory disease
- To screen for occupational disease
- To screen smokers for early signs of disease

CONTRAINDICATIONS TO PERFORMING SPIROMETRY

Absolute

- COVID
- Hemoptysis of unknown origin
- Active Infection e.g. TB

Relative

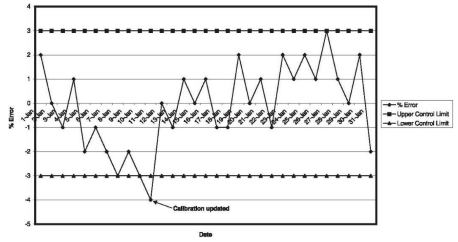
- Recent eye surgery or increased intra ocular pressure
- Ruptured tympanic membrane
- Acute disorders affecting test performance such as nausea and vomiting
- Recent MI or unstable cardiovascular status such as unstable angina or uncontrolled hypertension
- Pulmonary emboli
- Thoracic, abdominal or cerebral aneurysm
- Pneumothorax
- Patients must be free from respiratory infection 4-6 weeks
- Recent CVA

Verification/Calibration of your spirometer

- Use a 3l syringe ideally
- Value should be within 3% (90mls) of the 3 litre syringe volume
- Syringe to be checked annually.
- Syringe kept at same temperature as spirometer.

Daily Accuracy Check

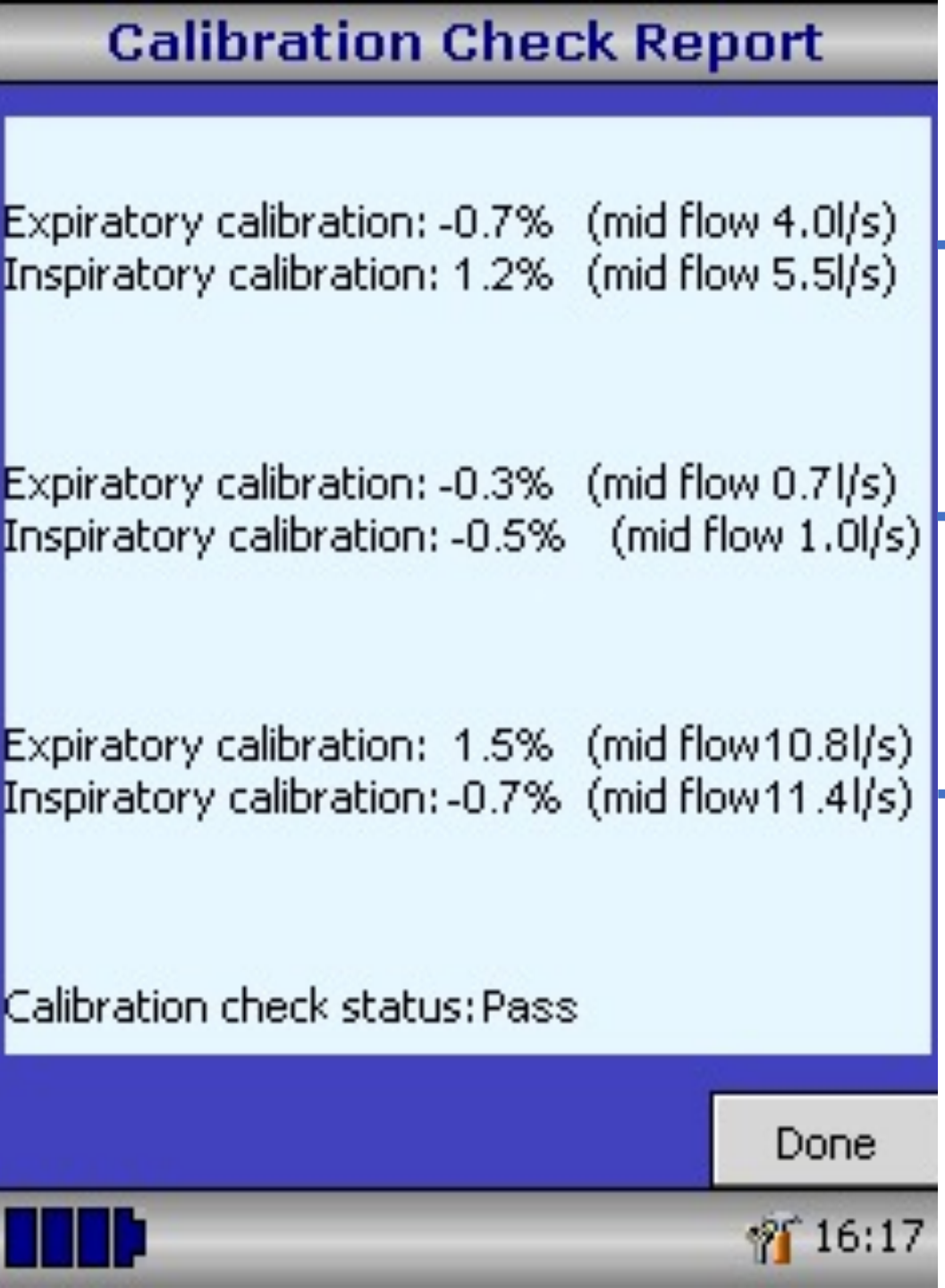




Users should have the facility to check spirometer accuracy on a regular basis using a 3-L syringe in accordance with all standards and guidelines.

<u>If 3 litre syringe is not available consider co ducting a Biological Control</u>

- The person performing the quality control should have normal lung function.
- Results should not vary by more than 10% from the last time.
- Equipment should be calibrated if this is not the case.



Check the 3 different flow rates are accurate – as a "pass" only refers to the volume.

Mid-flow rates

Low-flow rates

High-flow rates

Calibration verification figures for the flow rates

- Low -0-0.9l/s
- Medium 2-5/6 l/s
- High 7-12l/s

- CareFusion Micro-loop & Micro-lab

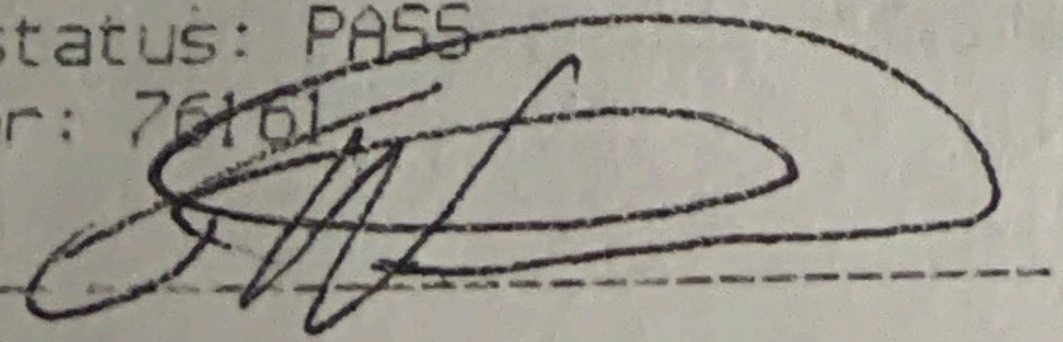
Spirometer Model: MicroLoop Mk8
Serial Number: 8549
Syringe Size: 3 Litres
Manoeuvre Type: Expiratory and Inspiratory

		IDEAL (Litres)	MEAS (Litres)	ERROR (%)
Band (low 0 - 0.9l/s):				
Test 1	Expiratory Manoeuvre	3.00	2.94	-2.0
Test 1	Inspiratory Manoeuvre	3.00	3.07	2.3
Test 2	Expiratory Manoeuvre	3.00	2.96	-1.3
Test 2	Inspiratory Manoeuvre	3.00	3.05	1.7
Test 3	Expiratory Manoeuvre	3.00	2.97	-1.0
Test 3	Inspiratory Manoeuvre	3.00	3.08	2.7
Band (medium 1.6 - 4.5l/s):				
Test 1	Expiratory Manoeuvre	3.00	2.92	-2.7
Test 1	Inspiratory Manoeuvre	3.00	3.00	0.0
Test 2	Expiratory Manoeuvre	3.00	2.93	-2.3
Test 2	Inspiratory Manoeuvre	3.00	3.03	1.0
Test 3	Expiratory Manoeuvre	3.00	2.93	-2.3
Test 3	Inspiratory Manoeuvre	3.00	3.03	1.0
Band (high 7 - 12l/s):				
Test 1	Expiratory Manoeuvre	3.00	2.94	-2.0
Test 1	Inspiratory Manoeuvre	3.00	3.08	2.7
Test 2	Expiratory Manoeuvre	3.00	2.93	-2.3
Test 2	Inspiratory Manoeuvre	3.00	3.06	2.0
Test 3	Expiratory Manoeuvre	3.00	2.96	-1.3
Test 3	Inspiratory Manoeuvre	3.00	3.07	2.3

Calibration Verification: **PASSED**

Turbine transducer calibration check report

Transducer Serial Number: 50638
Last calibration check 21/01/20 17:24
Expiratory calibration: -1.0% (mid flow 3.2l/s) — Medium flow
Inspiratory calibration: -3.3% (mid flow 2.6l/s)
Expiratory calibration: + 2.7% (mid flow 0.7l/s) — Low flow
Inspiratory calibration: + 0.3% (mid flow 0.7l/s)
Expiratory calibration: + 0.7% (mid flow 9.2l/s) — High flow
Inspiratory calibration: -1.3% (mid flow 8.0l/s)
Calibration check status: PASS
Device Serial Number: 7616

Operator Signature: 

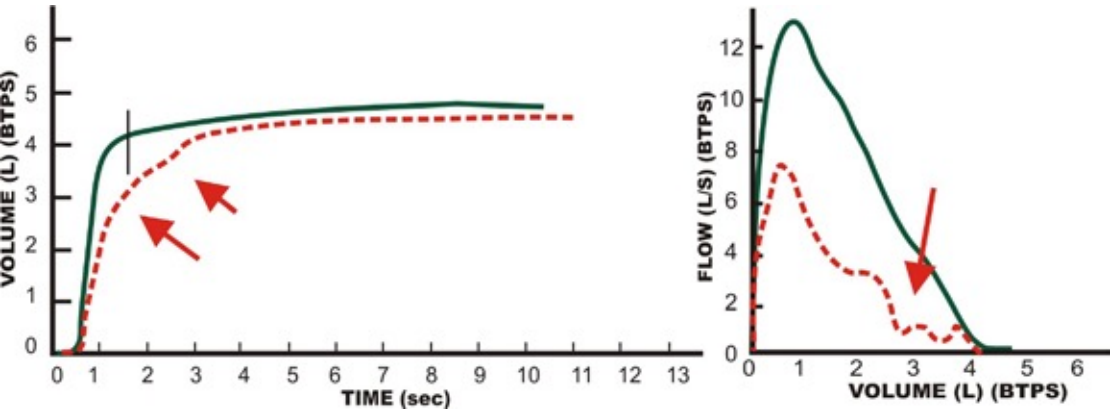
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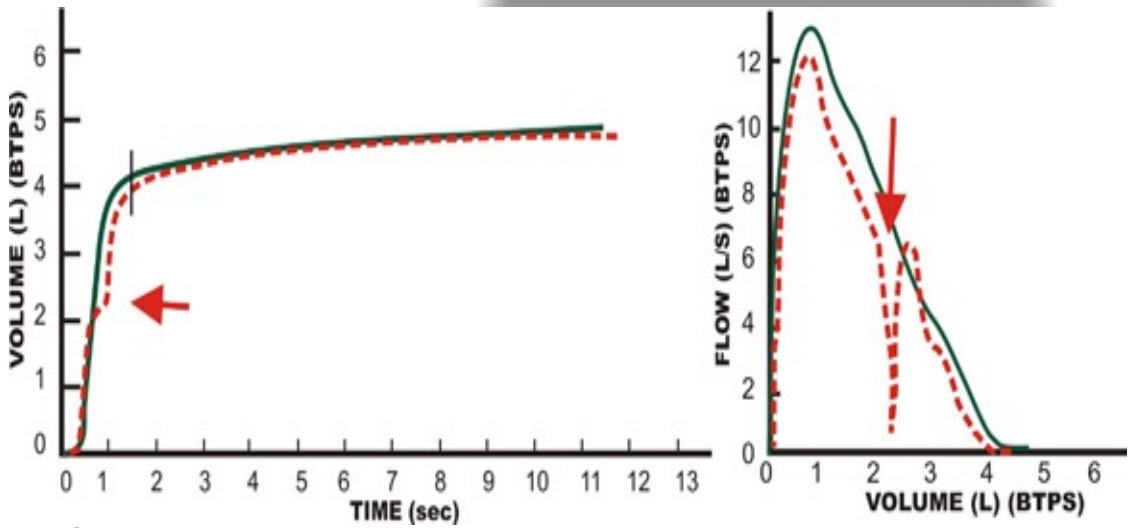
And **Rubbish in = Rubbish out**



=







Poor spirometry unworthy of interpretation

INTERPRETATION

Before interpretation the following criteria should be satisfied:-

The demographics are 100% accurate

That the best 2 blows are within 5% or 100 ml of each other for both VC, FVC & FEV_1

The graphs are reflective of excellent technique - VT trace is smooth, convex upwards and free from irregularities

That the reading has been continued over sufficient time for a plateau to have been reached.

Do the traces show any evidence of poor technique, extra breath or cough?

Spirometry gives us 4 important measurements

1. **RVC, EVC, SVC or VC-** is the volume or air that can be expelled slowly from a position of full inspiration to a position of full expiration in one breath and is expressed as % predicted

2. **FVC** – Is the total volume of air that the patient can expel forcibly from a position of full inspiration to a position of full expiration in one breathe and is expressed as % predicted

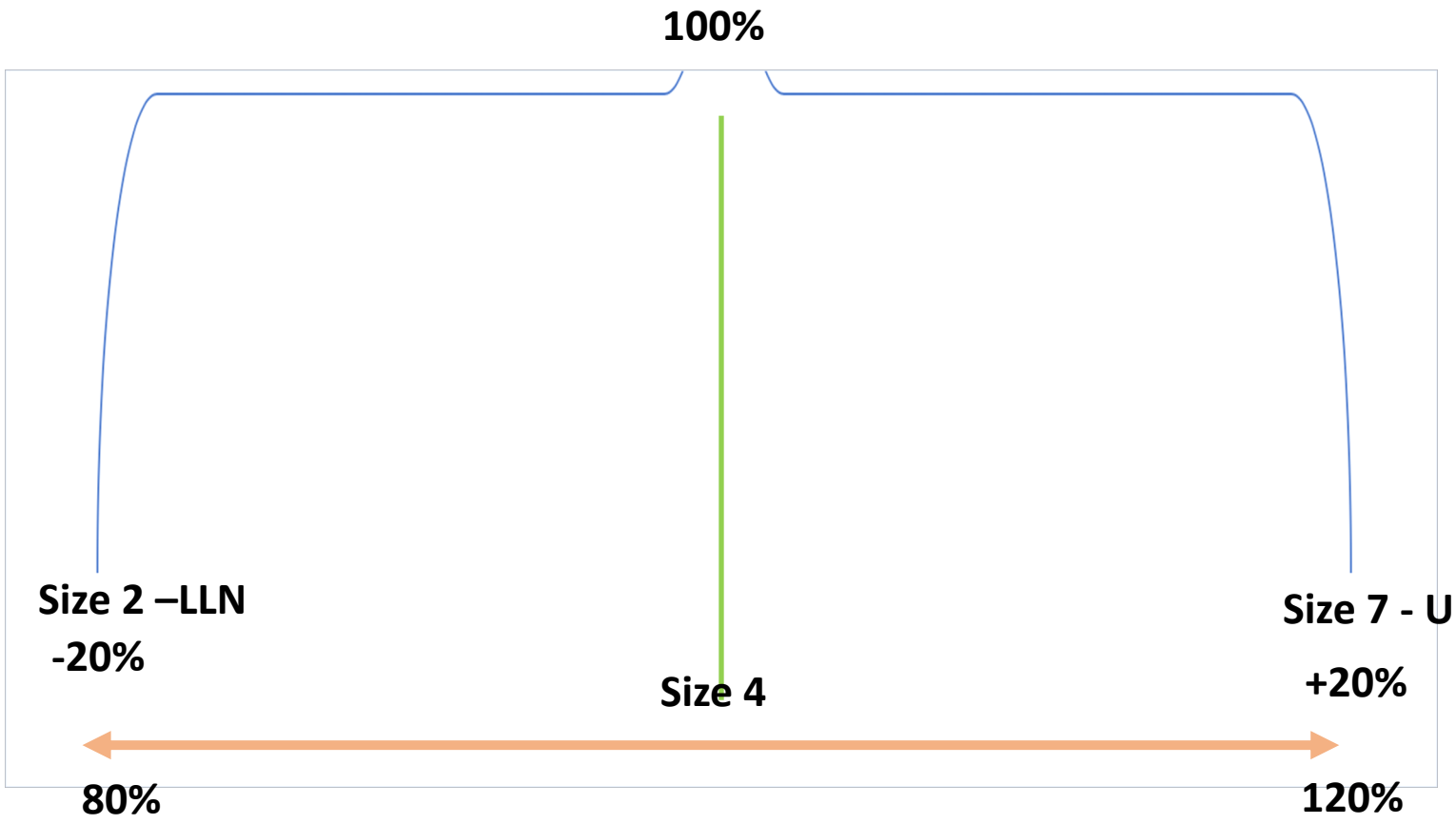
3. **FEV_1** – is the volume of air that the patient expels in the first second of forced manoeuvre and is expressed as % predicted

4. FEV_1 / FVC (VC) also known as the ratio – and is calculated by dividing the volume of gas expelled in the first second by the total "largest' amount of gas expelled in total and is expressed as a percentage – **but is NOT a percentage of predicted**

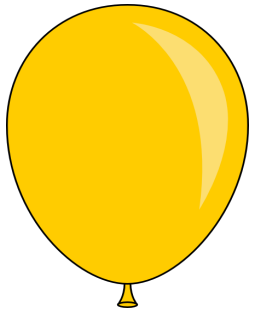
Percent predicted explained using Shoe sizes



‘The Bell curve of normality”
Calculating % predicted
‘For shoes’

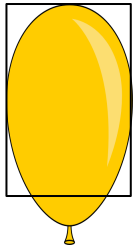


Balloon visuals to help grasp the 4 potential spirometry pictures



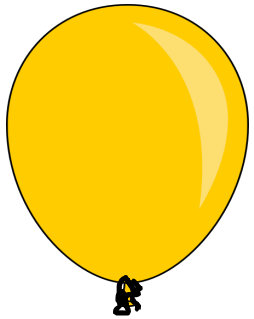
Normal Balloon

FVC & VC = 4.00L = 100%pred
FEV_1 = 3.00L = 100% pred
Ratio of FEV_1/VC and FEV_1/FVC = 75%



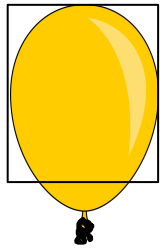
Restricted Balloon

Note the airway is normal but the capacity is reduced
FVC & VC = 2.00L= 50% pred
FEV_1 = 1.50L – 50% pred
Ratio of FEV_1/VC and FEV_1/FVC = 75%



Obstructed Balloon

Note the airway is damaged and narrowed
FVC & VC = 4.00L = 100% pred
FEV_1 = 2.00L = 66% pred
Ratio of FEV_1/VC and FEV_1/FVC = 50%



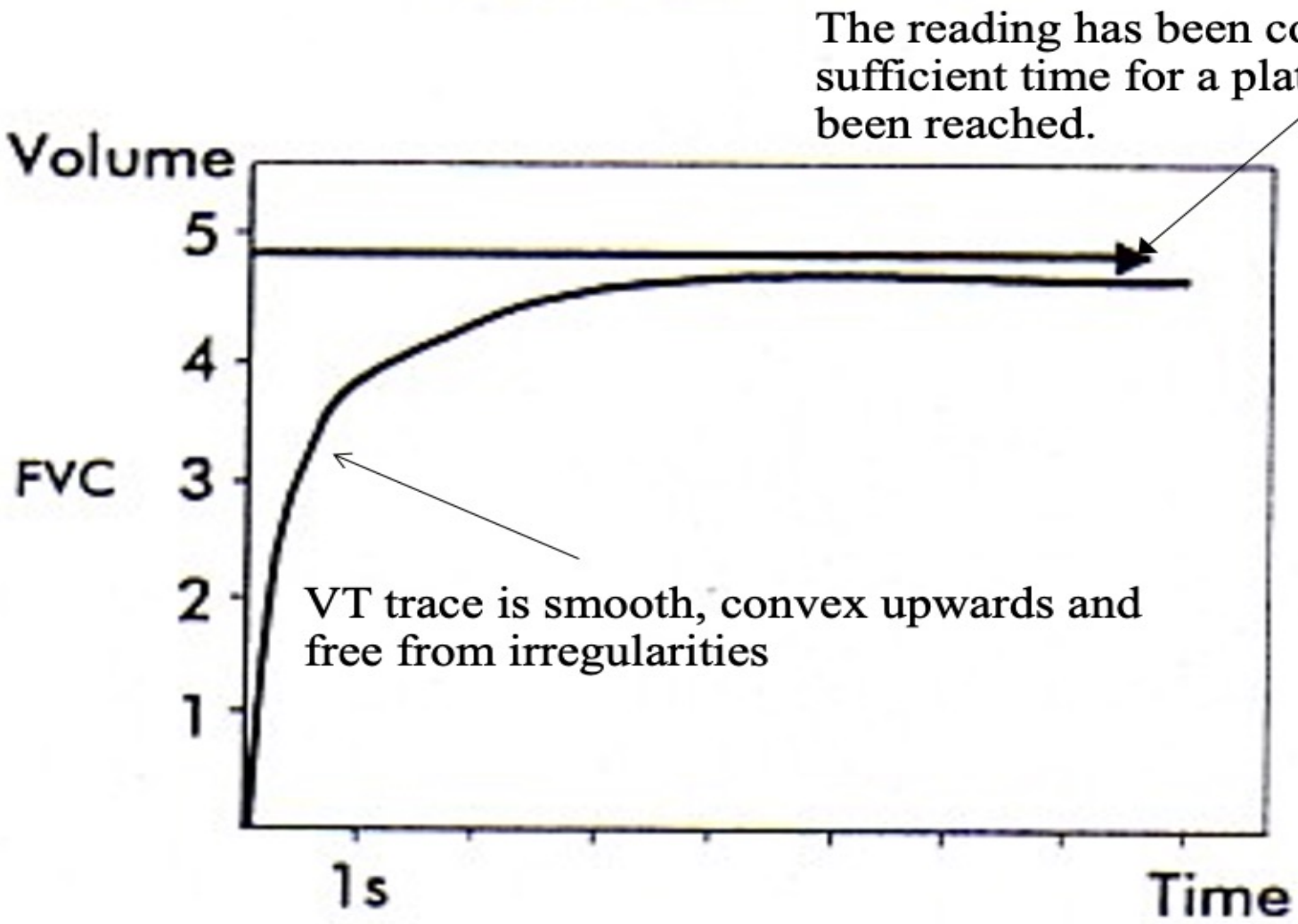
Combined obstructed and Restriction

Note the airway is damaged and narrowed and capacity is reduced
FVC & VC = 2.00L = 50% pred
FEV_1 = 1.00L = 33% pred
Ratio of FEV_1/VC and FEV_1/FVC = 50%

Barrett McGrath EMS Ltd (2017)

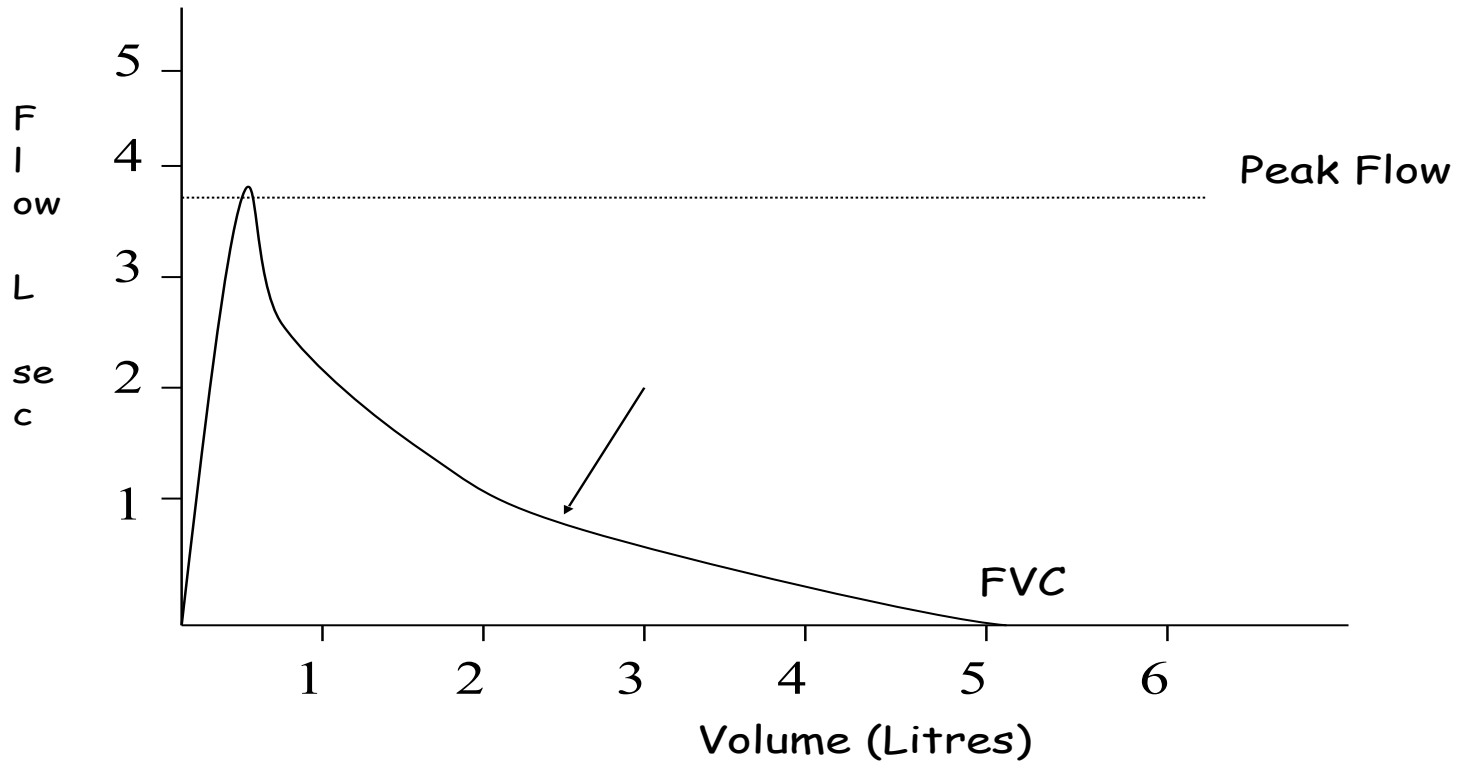
Speakers own data

Normal FVC


The reading has been continued over sufficient time for a plateau to have been reached.
Volume
5
4
FVC
3
2
1
VT trace is smooth, convex upwards and free from irregularities
1s
Time

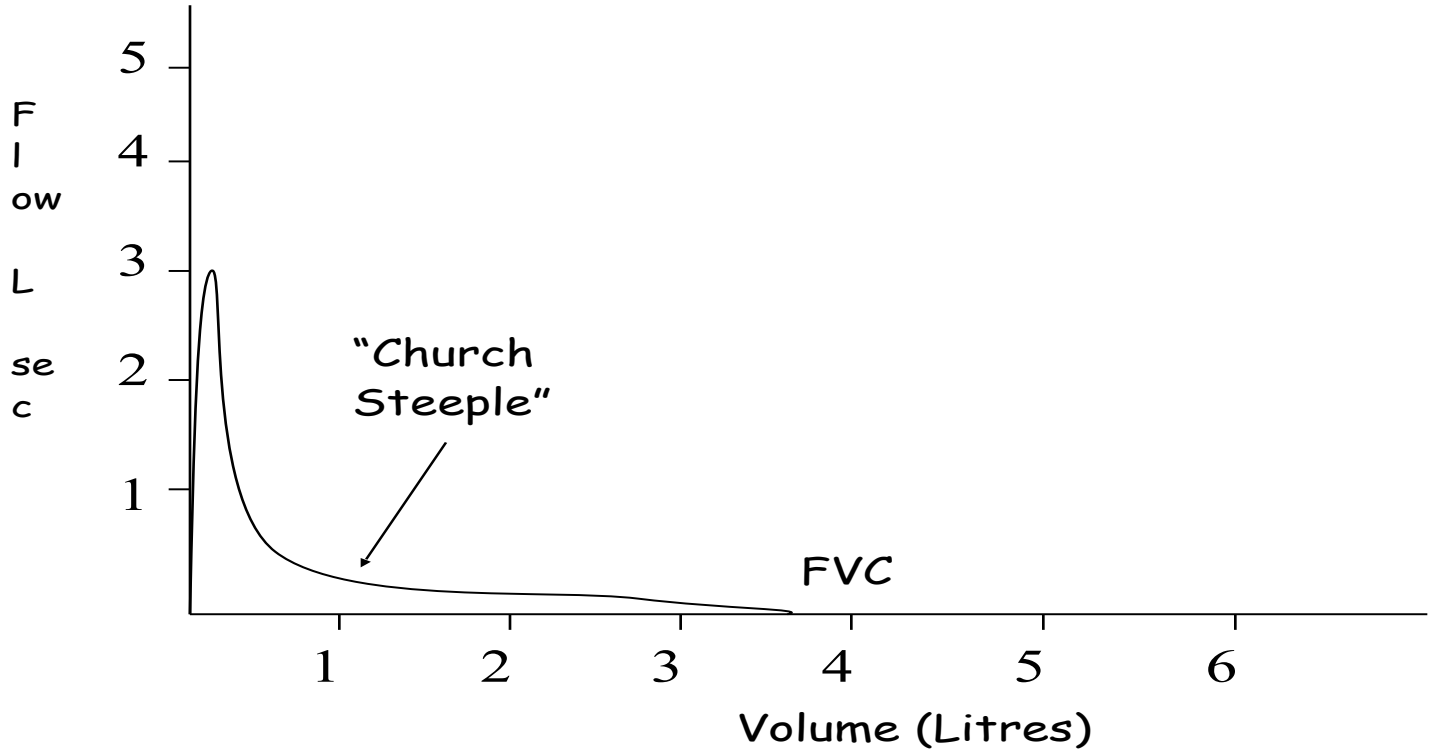
A Flow Volume Trace

Obstructed flow volume trace



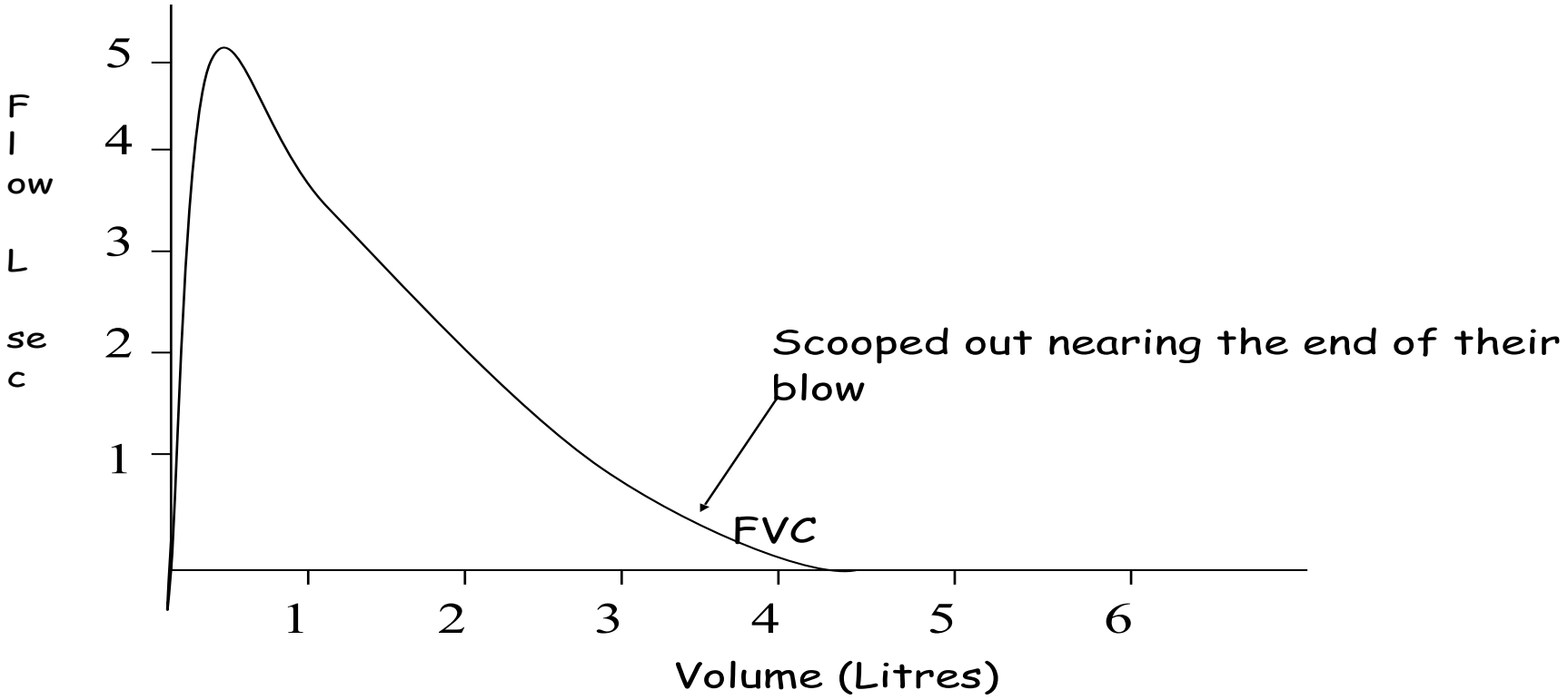
A Flow Volume Trace

Severe Obstructed flow volume trace



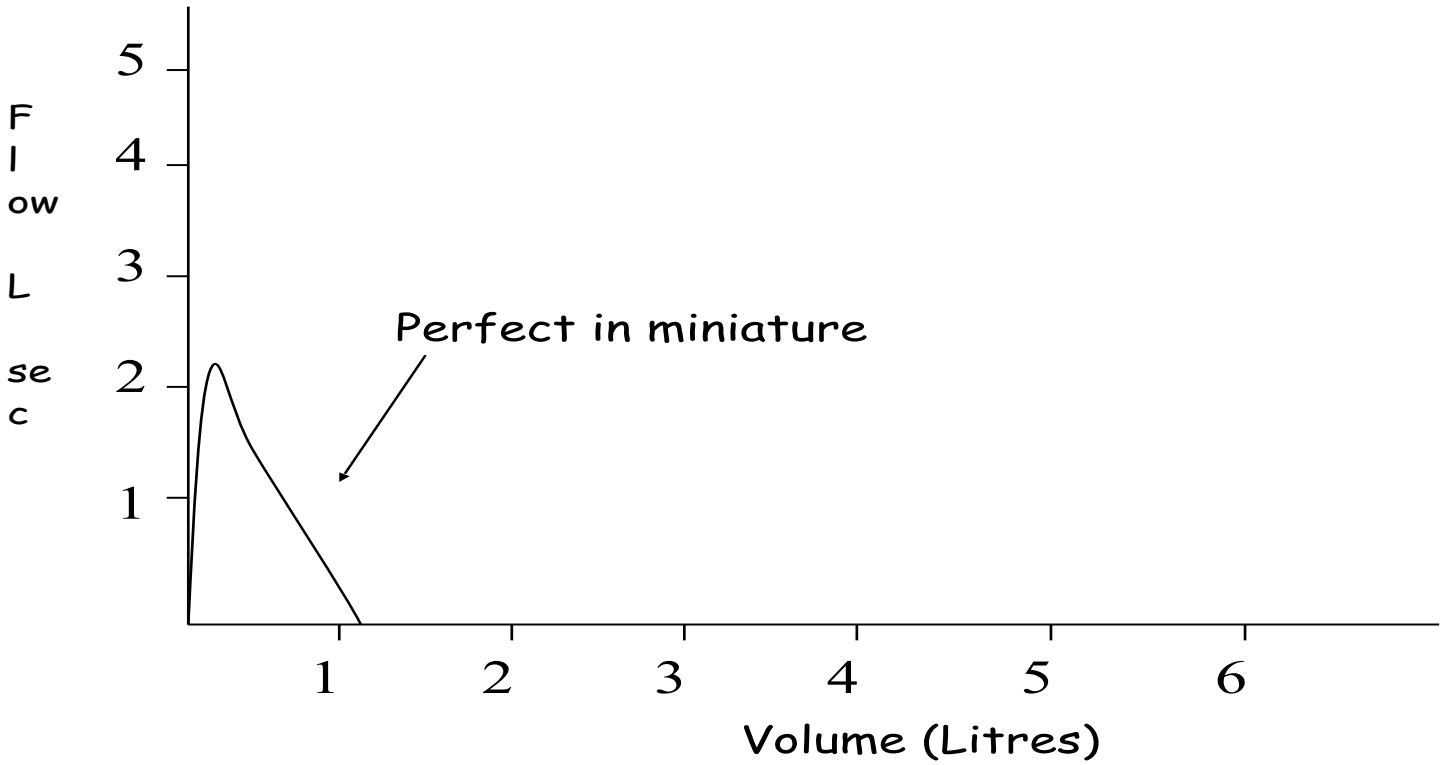
A Flow Volume Trace

Normal flow volume trace in older subjects



A Flow Volume Trace

Restricted flow volume trace



What are the MEFs & FEFs ?

The MEFs and the FEFs are essentially the same

- MEFs = Mid Expiratory Flow – 75 ⟶ 25
- FEFs = Flow Expiratory Time – 25 ⟶ 75

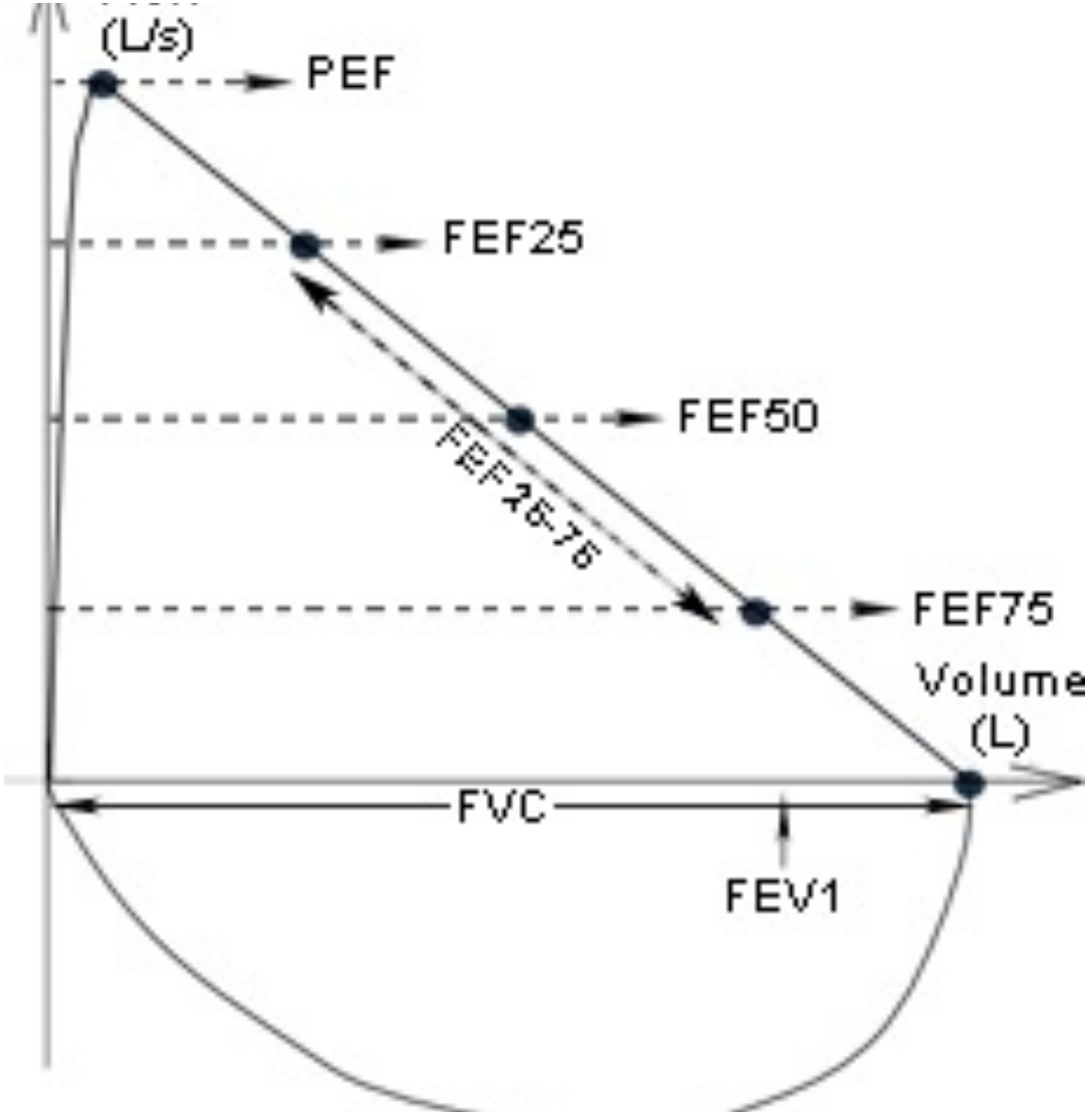
Normal predicted values is accepted to be >50% but is widely recognised that values of >80% is preferred for many reasons.

They measure the flow from the smallest air-conducting passages in l/s and can indicate early COPD among other things

*The MMEFs (the average of the three readings is the best reading to assess the mean flow from the smallest air conducting passages)

FEFs Explained

1. This is the most important curve in spirometry.
   A normal Flow-Volume loop begins on the X-axis (Volume axis): at the start of the test both flow and volume are equal to zero. Directly after this starting point the curve rapidly mounts to a peak: Peak (Expiratory) Flow. If the test is performed correctly, this PEF is attained within the first 150 milliseconds of the test. The Peak Flow is a measure for the air expired from the large upper airways (trachea-bronchi).
2. After the PEF the curve descends (=the flow diminishes) as more air is expired. After 25% of the total expired volume, the parameter FEF25 is reached.
3. Halfway the curve (when the patient has expired half of the volume) the FEF50 is reached: Forced Expiratory Flow at 50% of the FVC.
4. After 75% the parameter FEF75 is reached.



QUICK REFERENCES

	NORMAL	OBSTRUCTED	RESTRICTED	COMBINED
RVC	>80% PRED	>80% PRED NORMAL	DOWN BELOW 80%	DOWN
FEV1	>80%PRED	NORMAL OR DOWN	DOWN BELOW 80%	DOWN
FVC	>80%PRED	NORMAL	DOWN BELOW 80%	DOWN
FEV1/VC	>70%	BELOW 70%	NORMAL OR HIGH	DOWN
FEV1/FVC	>70%	BELOW 70%	NORMAL OR HIGH	DOWN

Normal range for FEV1, RVC AND FVC = 80-120% of predicted.



Now let us do a few interpretations together

Interpretation of the results using the 4-step rule

1. **Demographics –** *age, height in bare feet, birth gender and ethnicity*
2. **Reproducibility –** *minimum of three relaxed three forced blows with the best 2 VCs, FVCs and FEV_1s < 5% and 100mls to gain grade A*
3. **Graphs –** *no evidence of a short blow, slow start cough or extra breath*
4. **Figures –** *look at the VC and FVC are they >80% predicted – is the VC higher than the FVC – if so consider air trapping*

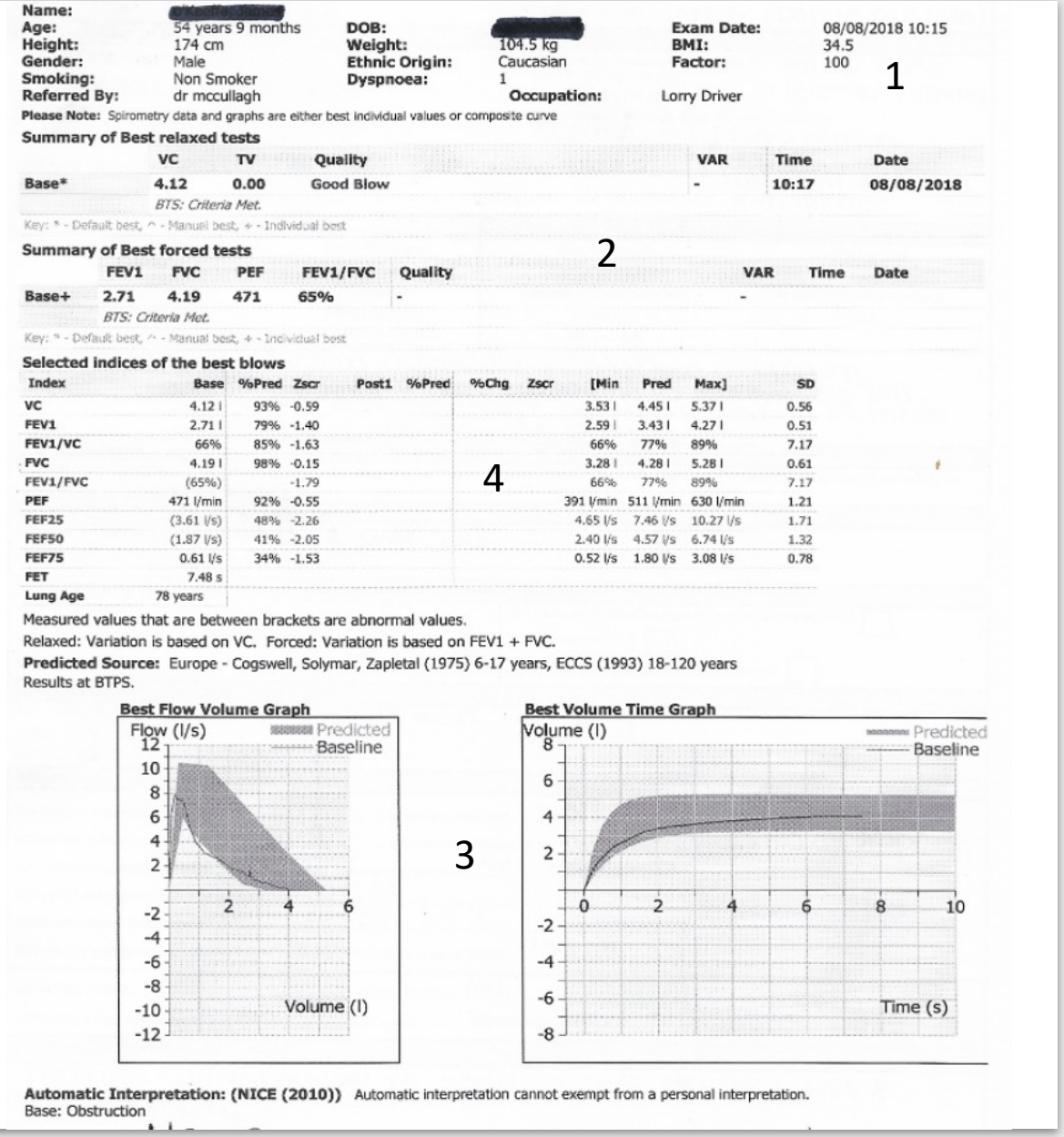
   Then look at the ratios – FEV_1/VC or FEV_1/FVC using the ration against the highest capacity

   If the ratio is <70% - look at the FEV_1 to classify the obstruction

Accurate Interpretation of the results

1. Demographics – age, height in bare feet, birth gender and ethnicity
2. Reproducibility – minimum of three relaxed three forced blows with the best 2 VCs, FVCs and FEV_1s < 5% and 100mls to gain grade A
3. Graphs – no evidence of a short blow, slow start cough or extra breath
4. Figures – look at the VC and FVC are they >80% predicted – is the VC higher than the FVC? then look at the ratios – FEV_1/VC or FEV_1/FVC using the ration against the highest capacity if the ratio is <70% - look at the FEV_1 to classify the obstruction

Now try and interpret this reading using the 1,2,3,4 approach above



Name:	[redacted]						
Age:	54 years 9 months	**DOB:**	[redacted]		**Exam Date:**	08/08/2018 10:15	
Height:	174 cm	**Weight:**	104.5 kg		**BMI:**	34.5	
Gender:	Male	**Ethnic Origin:**	Caucasian		**Factor:**	100	
Smoking:	Non Smoker	**Dyspnoea:**	1				
Referred By:	dr mccullagh		**Occupation:**	Lorry Driver			

1

Please Note: Spirometry data and graphs are either best individual values or composite curve

Summary of Best relaxed tests

	VC	TV	Quality	VAR	Time	Date
Base*	**4.12**	**0.00**	**Good Blow**	-	**10:17**	**08/08/2018**
	BTS: Criteria Met.					

Key: * - Default best, ^ - Manual best, + - Individual best

Summary of Best forced tests

2

	FEV1	FVC	PEF	FEV1/FVC	Quality	VAR	Time	Date
Base+	**2.71**	**4.19**	**471**	**65%**	-	-		
	BTS: Criteria Met.							

Key: * - Default best, ^ - Manual best, + - Individual best

Selected indices of the best blows

4

Index	Base	%Pred	Zscr	Post1	%Pred	%Chg	Zscr	[Min	Pred	Max]	SD
VC	4.12 l	93%	-0.59					3.53 l	4.45 l	5.37 l	0.56
FEV1	2.71 l	79%	-1.40					2.59 l	3.43 l	4.27 l	0.51
FEV1/VC	66%	85%	-1.63					66%	77%	89%	7.17
FVC	4.19 l	98%	-0.15					3.28 l	4.28 l	5.28 l	0.61
FEV1/FVC	(65%)		-1.79					66%	77%	89%	7.17
PEF	471 l/min	92%	-0.55					391 l/min	511 l/min	630 l/min	1.21
FEF25	(3.61 l/s)	48%	-2.26					4.65 l/s	7.46 l/s	10.27 l/s	1.71
FEF50	(1.87 l/s)	41%	-2.05					2.40 l/s	4.57 l/s	6.74 l/s	1.32
FEF75	0.61 l/s	34%	-1.53					0.52 l/s	1.80 l/s	3.08 l/s	0.78
FET	7.48 s										
Lung Age	78 years										

Measured values that are between brackets are abnormal values.

Relaxed: Variation is based on VC. Forced: Variation is based on FEV1 + FVC.

Predicted Source: Europe - Cogswell, Solymar, Zapletal (1975) 6-17 years, ECCS (1993) 18-120 years

Results at BTPS.

Best Flow Volume Graph

3

Best Volume Time Graph

Automatic Interpretation: (NICE (2010)) Automatic interpretation cannot exempt from a personal interpretation.

Base: Obstruction

Airflow obstruction

Airflow obstruction is defined as reduced FEV_1/FVC or FEV_1/VC ratio <70% (< 0.7) in COPD



Reversible



Irreversible

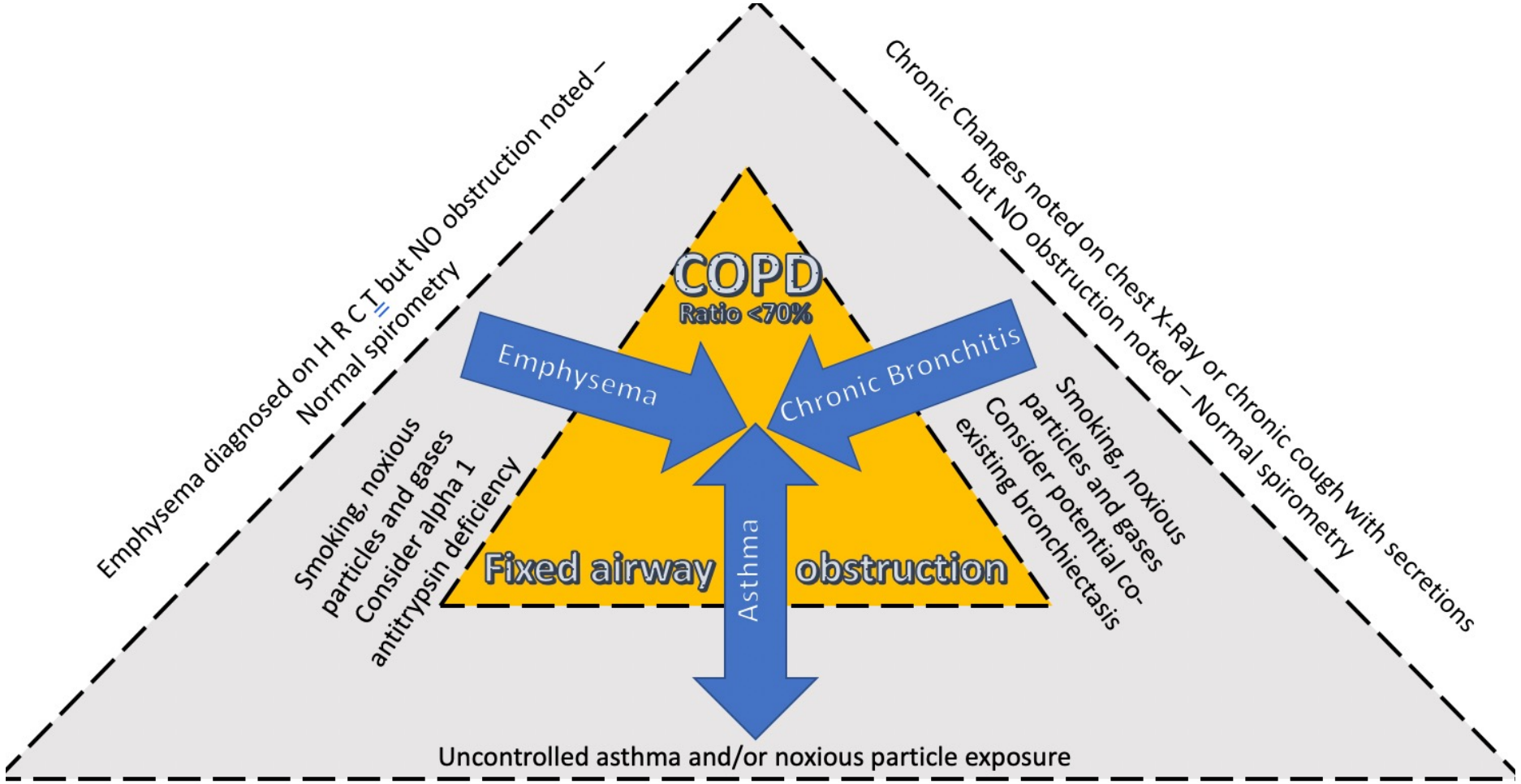
And Remember

ONLY conduct a reversibility study on a patient who demonstrates OBSTRUCTION

GOLD 2019


CALL TO ACTION

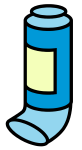
Remember spirometry is <u>essential</u> to confirming a COPD diagnosis and classify the degree of obstruction
And a COPD diagnosis can <u>only</u> be confirmed if the FEV_1/FVC or VC ratio is FIXED below 70%



BARRETT McGRATH
Education Mentoring Services (EMS) Ltd



Reversibility



SABA reversibility

Administer (usually 4 x 100mcg salbutamol as single puffs via spacer) or 2.5mg via nebulizer if spacer not available or cannot be used



Repeat spirometry after 15 - 20 minutes



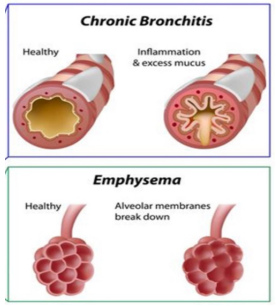
Steroid reversibility



30 mgs Prednisolone daily for 5 days & repeat a post BD SPIROMETRY on day 5 if possible

A positive response is considered as a 200ml & 12% increase in FEV1 and may be indicative of asthma





BTS/SIGN 2019

1

Sex: Female Age: 64
Factor: 100(Non-Caucasian)
Height: 153cm Weight: 76kg
BMI: 32.5

2

	FEV1	FVC	PEF	Var	Quality	Time:	Date:
Base	1.36	1.75	283	0%	Good blow	11:40	25-03-04
Base	1.34	1.74	282	0%	Good blow	11:40	25-03-04
Base	1.37	1.65	290	-2%	Good blow	11:40	25-03-04
Post 1	1.39	1.81	241	0%	Good blow	12:06	25-03-04
Post 1	1.37	1.78	244	-4%	Good blow	12:06	25-03-04
Post 1	1.38	1.66	277	-5%	Good blow	12:06	25-03-04

Variation is based on FEV1 + FVC

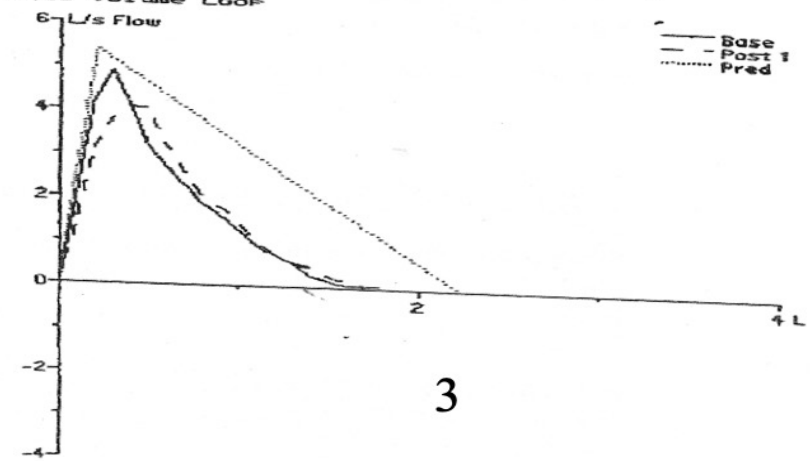
Best Spirometry Result:

	Base	%Pr	Normal Min	Normal Pred	Normal Max	Post1 Post	Post1 %Pr	Post1 %Chg	
FVC	1.79	81	1.50	2.19	2.88	1.38	63	-23	L
FEV1	1.36	73	1.22	1.84	2.46	1.39	75	2	L
PEF	1.75	78	1.51	2.22	2.93	1.81	81	3	L
FEV1/FVC	283	87	234	323	412	241	74	-15	L/M
MVV(ind)	78	101	66	77	88	77	99	-1	%
Lung Age: 82	51.8	73	45.9	69.1	92.4	52.1	75	2	L

Interpretation: Restrictive disorder.

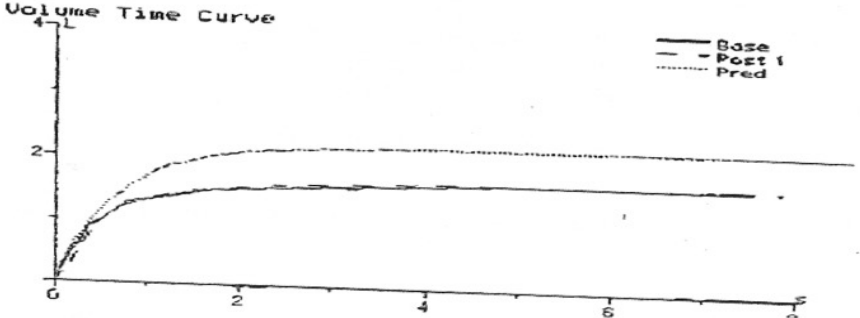
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Flow Volume Loop



3

Volume Time Curve



Normal Values: ECCS (Adult);
...tal, Solymar, Cogswell (Child)
...t BTPS.

