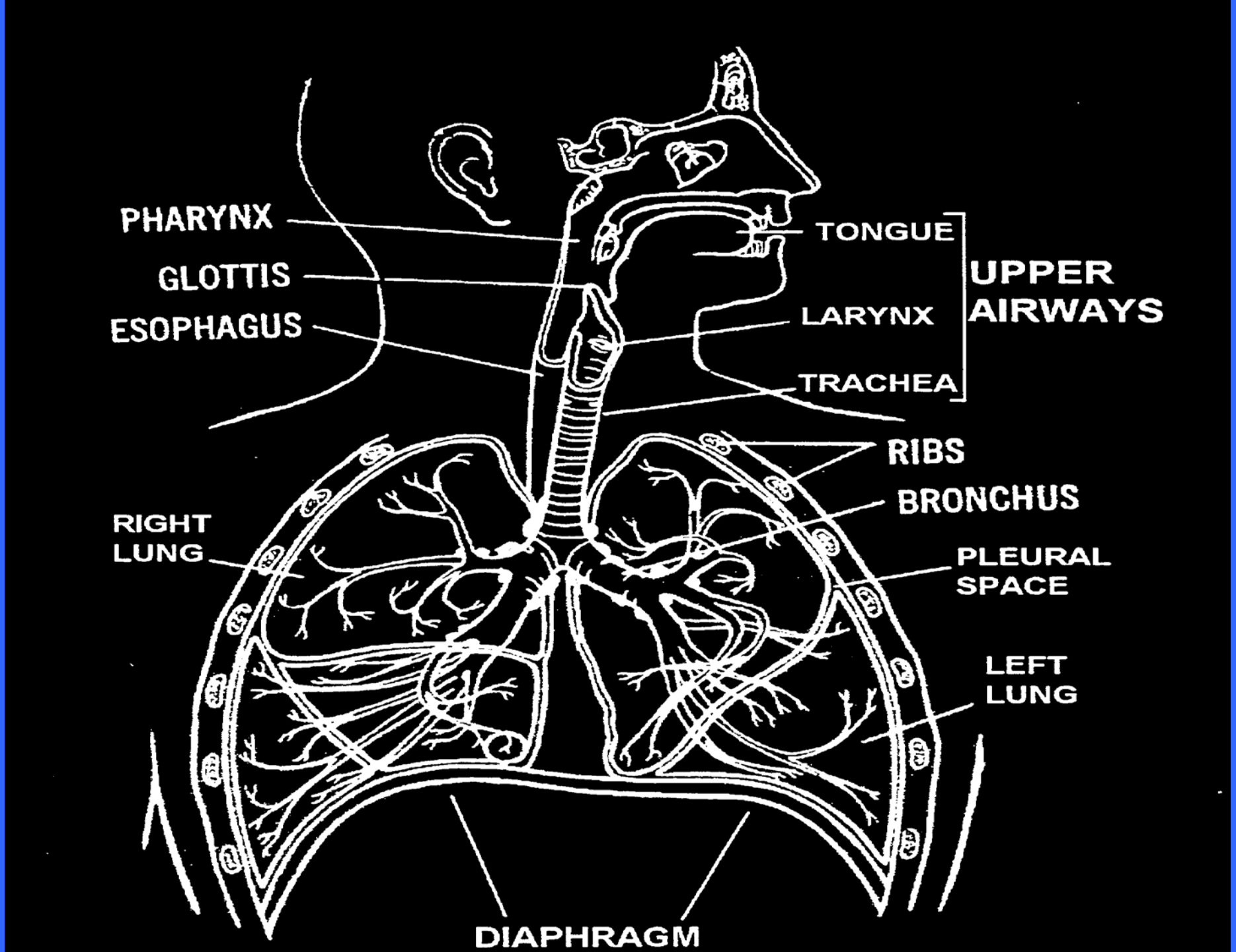
Spirometry
Overview for MESA

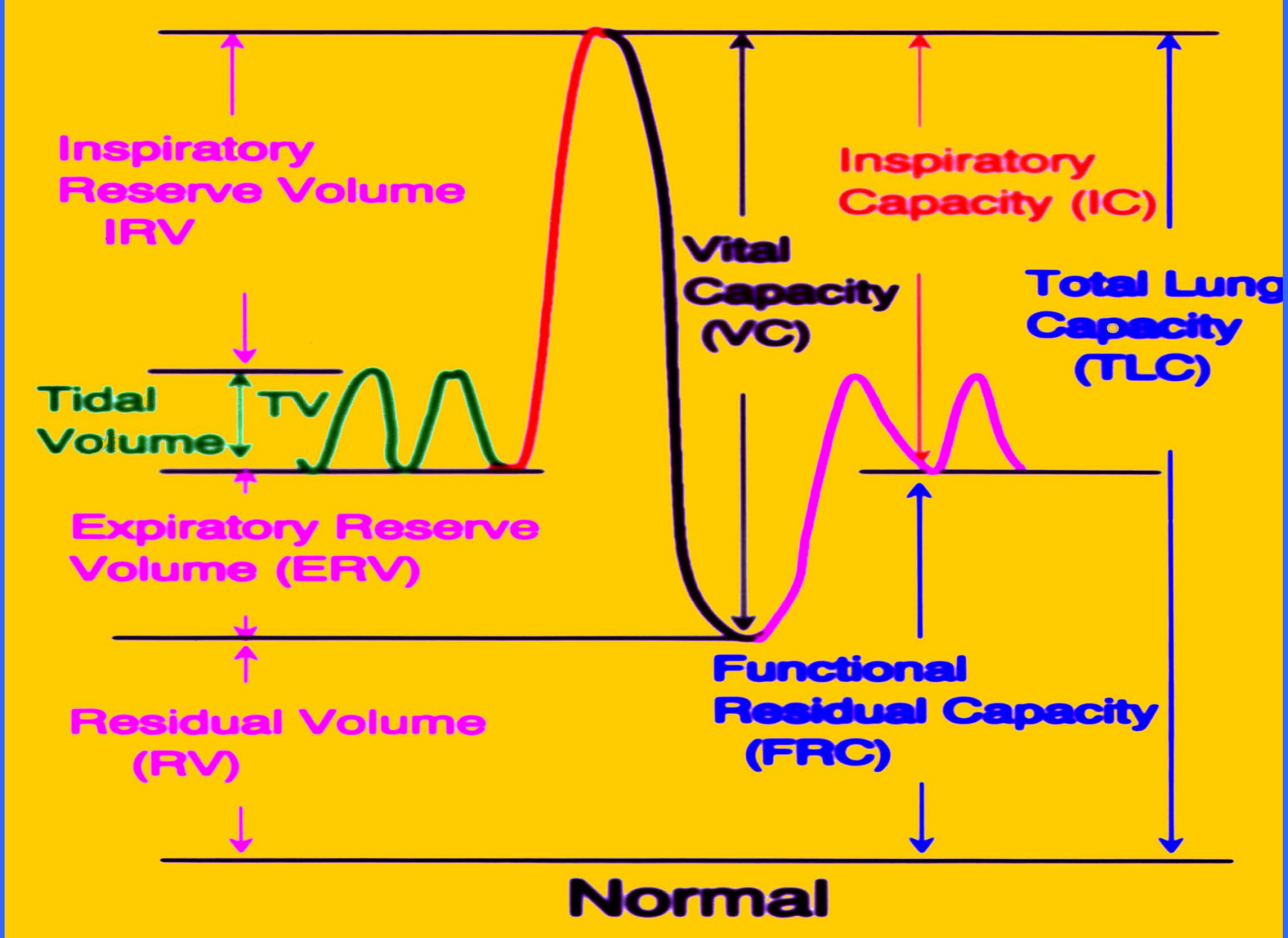
Preamble

- Course and training is same as prior exams
- Sensormetics/OMI equipment is old
- Spirometry training on the web is new!
- Training today on new spirometer
- Option for follow-up training
- Possible need for site visits

Outline

- Spirometry Basics
- How to obtain a good test
- Quality evaulation


PHARYNX
GLOTTIS
ESOPHAGUS
TONGUE
LARYNX
TRACHEA
UPPER AIRWAYS
RIBS
BRONCHUS
PLEURAL SPACE
RIGHT LUNG
LEFT LUNG
DIAPHRAGM


Inspiratory Reserve Volume IRV
Tidal Volume
TV
Expiratory Reserve Volume (ERV)
Residual Volume (RV)
Vital Capacity (VC)
Inspiratory Capacity (IC)
Total Lung Capacity (TLC)
Functional Residual Capacity (FRC)
Normal

Only two spirometry numbers are clinically important:

FEV1 = Forced Expiratory Volume in 1 second

FVC = Forced Vital Capacity

and their ratio: FEV1/FVC

FEV1

- The FEV1 tells you how *fast* the patient can exhale.
- The FEV1 is low when airways become obstructed.
- The average FEV1 for a man is about 3 liters.

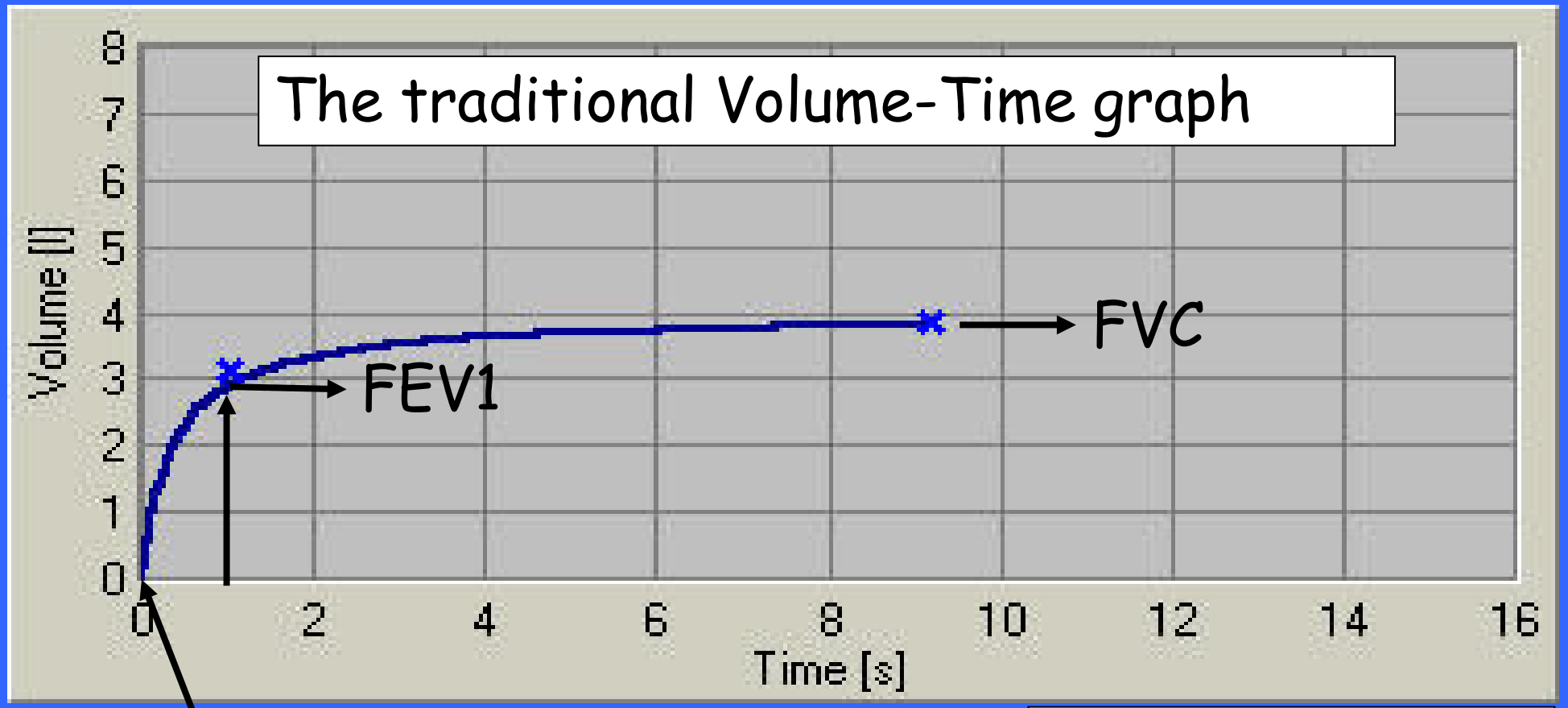
FVC

- The FVC tells you *how much* air the patient could exhale.
- The FVC falls when a patient can't inhale deeply or can't exhale completely.
- The average FVC for a man is about 4 liters (a gallon).

FEV1/FVC
"the ratio"

- A low ratio detects airway obstruction.
- It's usually expressed as a percentage (like 75%).
- About three-fourths of lung volume can normally be exhaled during the first second.
- So the ratio is normally above 65% to 75%.

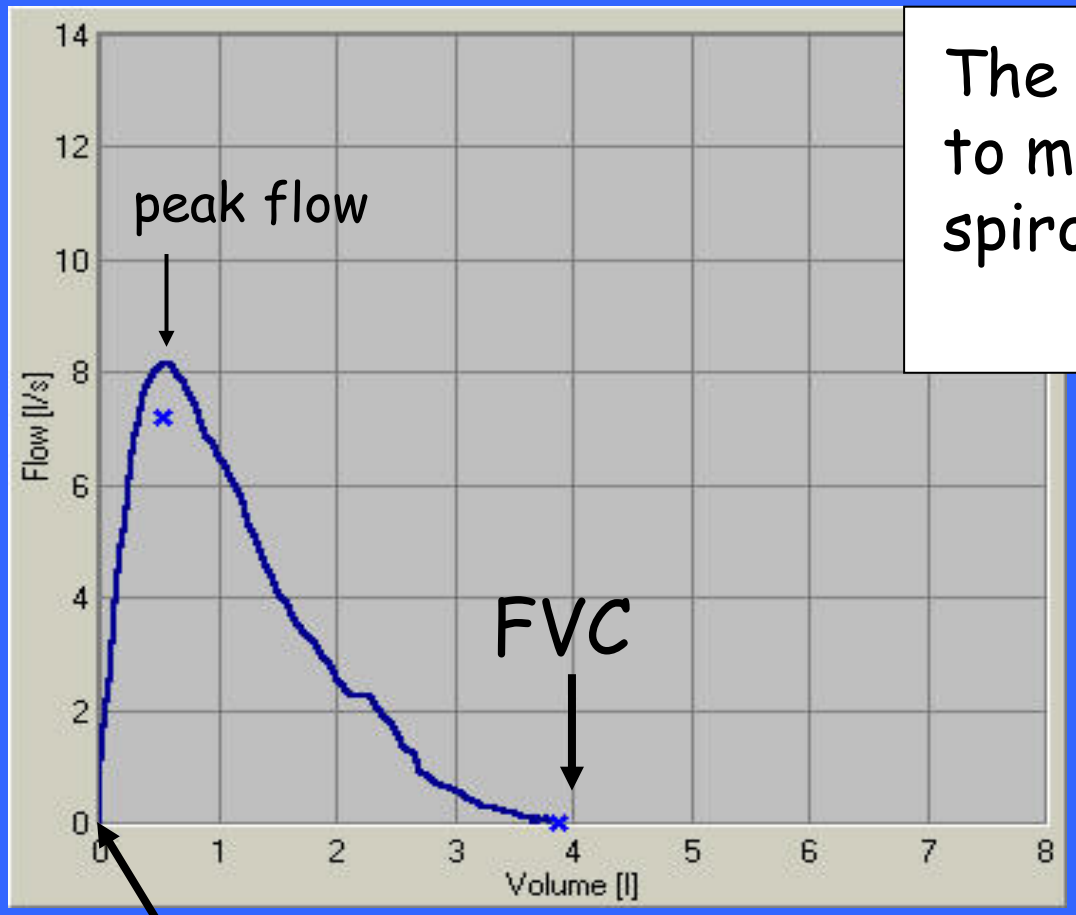
How are the numbers measured ?



The exhalation starts here

FEV1 = 2.9 liters
FVC = 3.9 liters
FEV1/FVC = 74%

The flow-volume curve

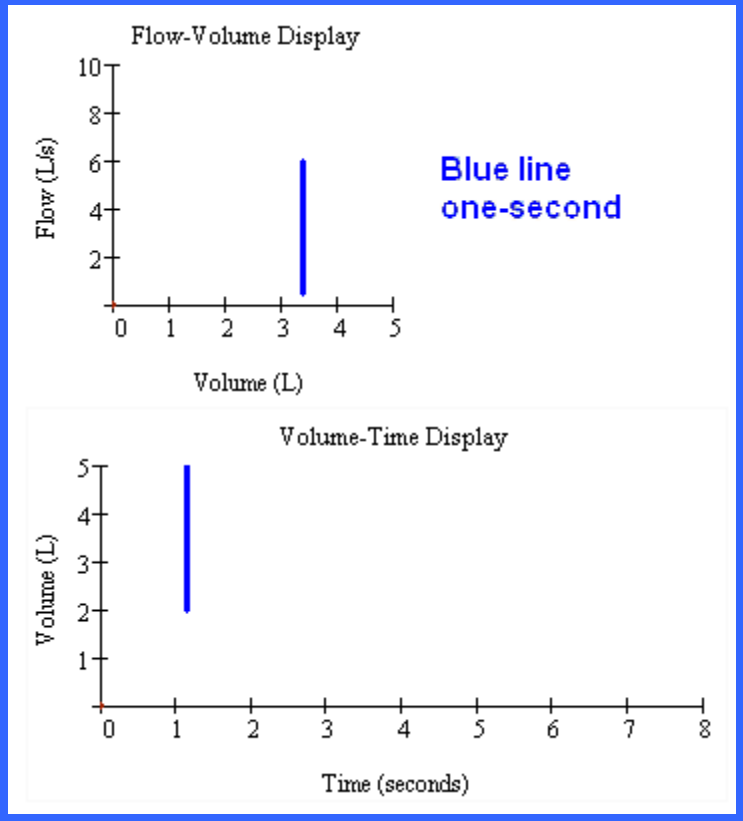


The exhalation starts here

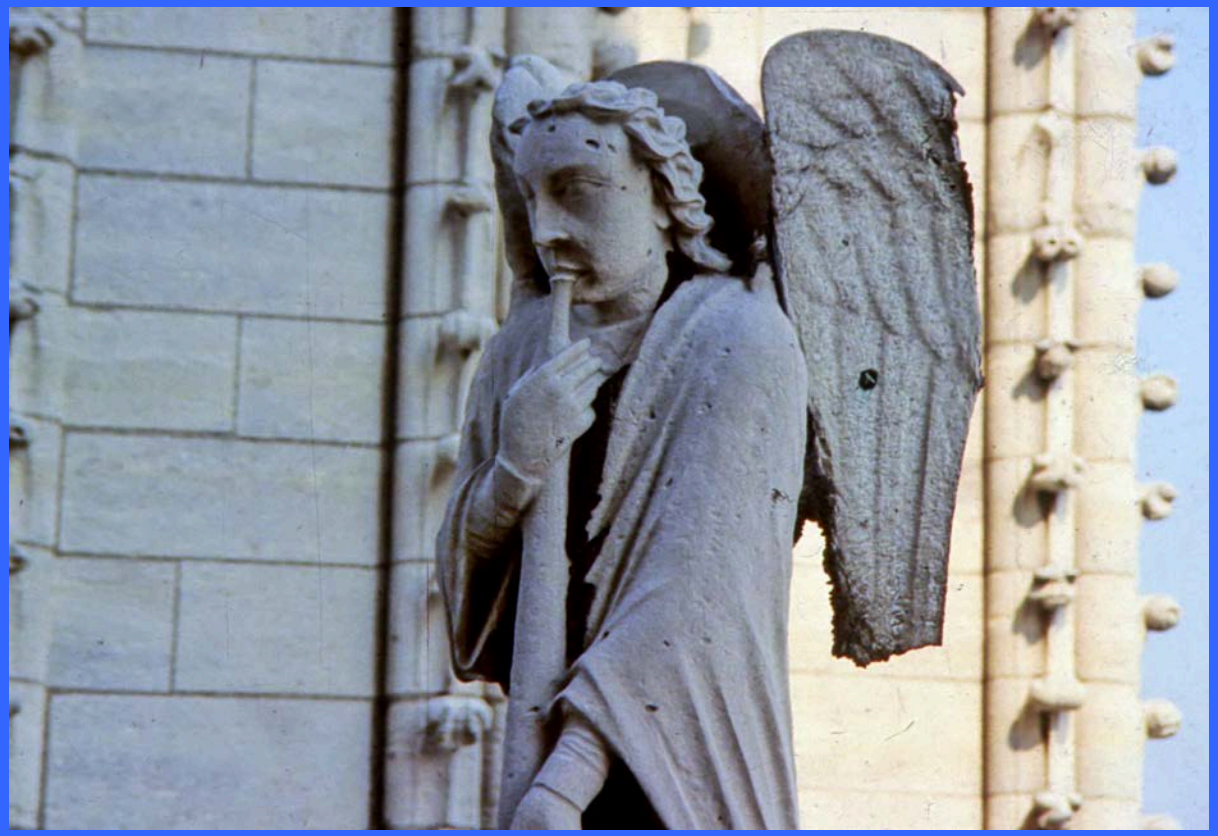
The F-V curve was invented to make the recognition of spirometry patterns easier.

- You can't measure the FEV1 from F-V curves.
- The blue Xs mark predicted values.

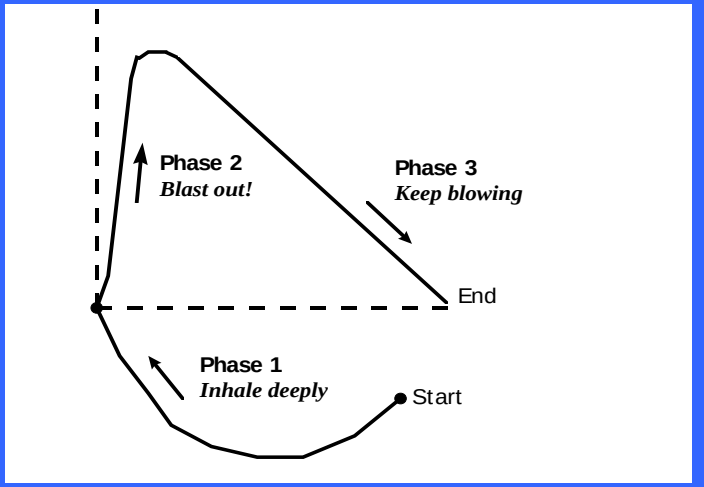
Sample Curve – Both Displays



Let's Do It !



3 phases of the test



#1 DEEP inhalation

#2 BLAST out

#3 Keep blowing until empty

Dramatically demonstrate these steps
using exaggerated body language (*before* they try it).

Basic instructions for coaching patients

- Phase 1
  - Deeep initial **inhalation**
  - Mouthpiece on the tongue. Seal lips.
- Phase 2
  - **Blast** out as hard and as fast as possible
  - Startle the patient to get a high peak flow
- Phase 3
  - Encourage complete exhalation

Watch the patient's body language.
Watch the patient's body language.

Patient Considerations

- Always wash your hands before each patient
- Dry your hands in front of them
  (to show them that you really care)
- Stay home if you have a cold or the flu !

Use noseclips. If this proves too distracting, they may hold their nose.

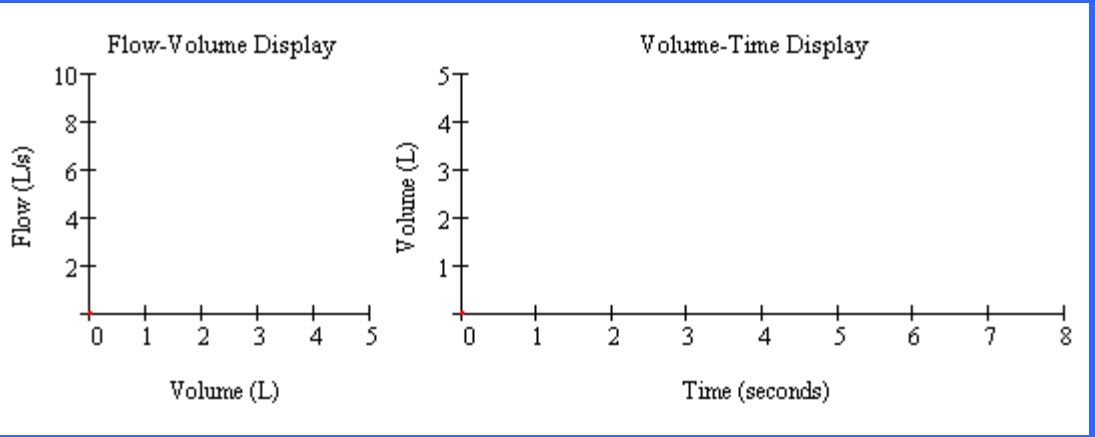
Test procedures

1. Wash your hands
2. Gain rapport (Chat and explain the reason for the test)
3. Explain the test (Deep inhalation, forced expiration)
4. Loosen tight clothing
5. Demonstrate test
6. Insert new mouthpiece
7. Coach maximal deep inhalation
8. Evaluate curve and re-instruct

What can go wrong?

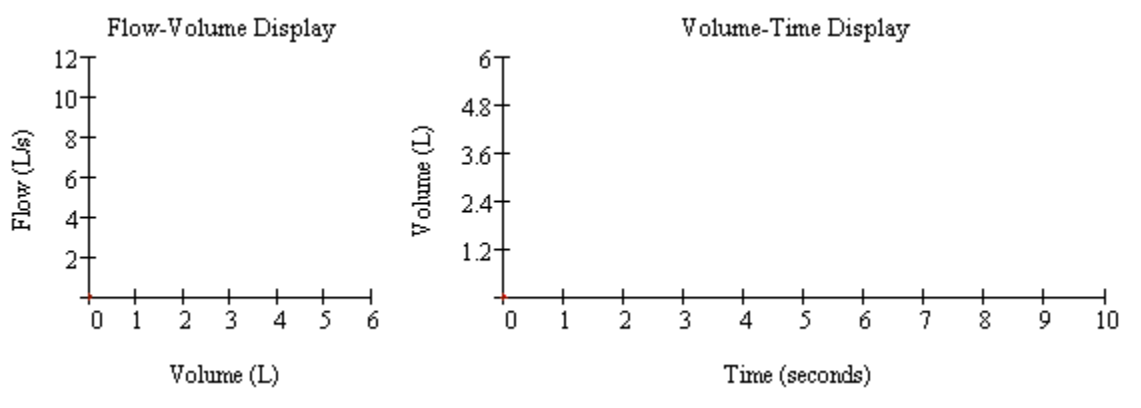
- Poor inhalation efforts
- Lack of a blast effort
- Cough during first second
- Short maneuvers
- Leak – mouthpiece or spirometer
- Variable effort
- Two few acceptable maneuvers
- Non-reproducible FVC or FEV1

Unacceptable Curve – Excessive Hesitation

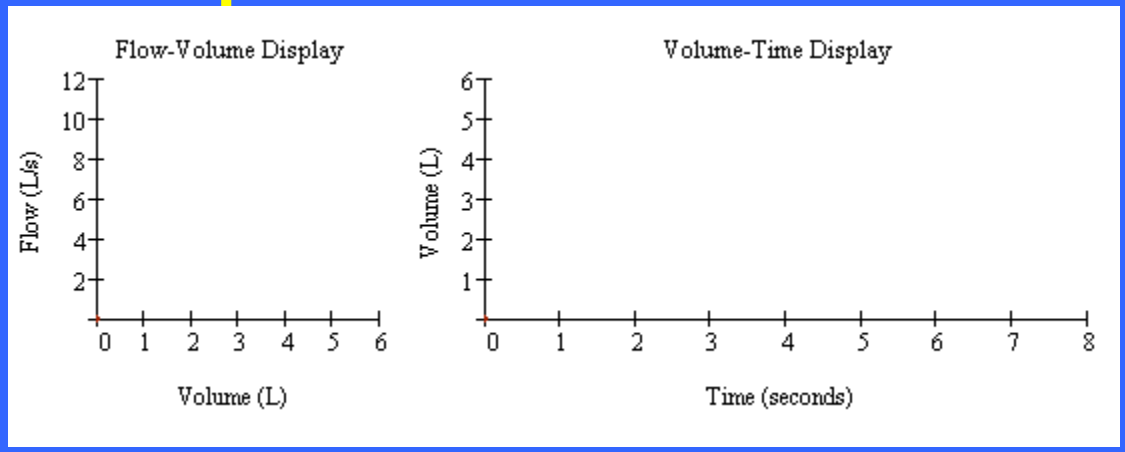


Coach Blast the air out

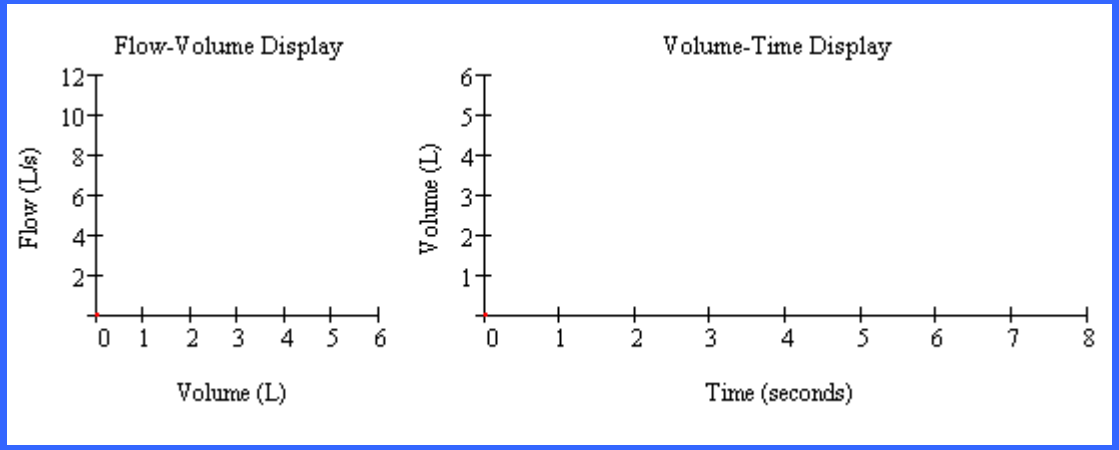
Unacceptable Curve – Cough during 1st second



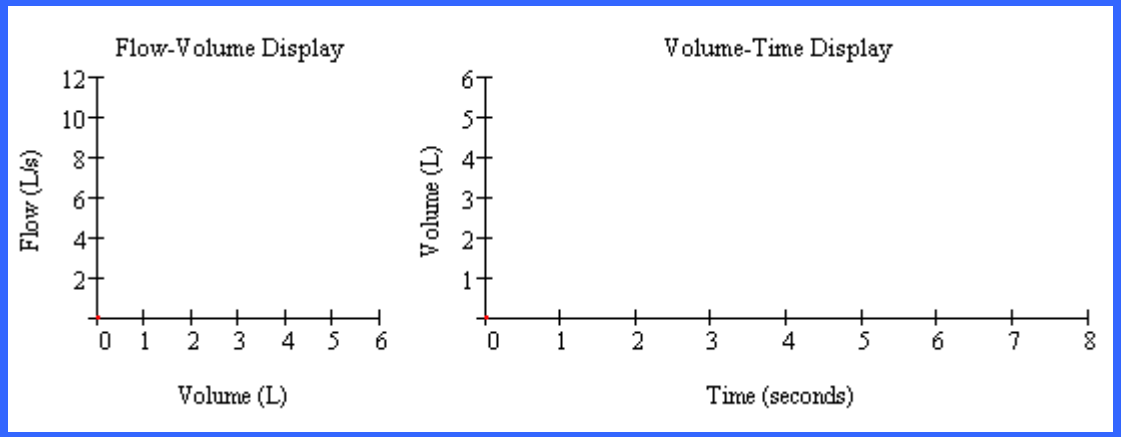
Unacceptable Curve - Variable Effort



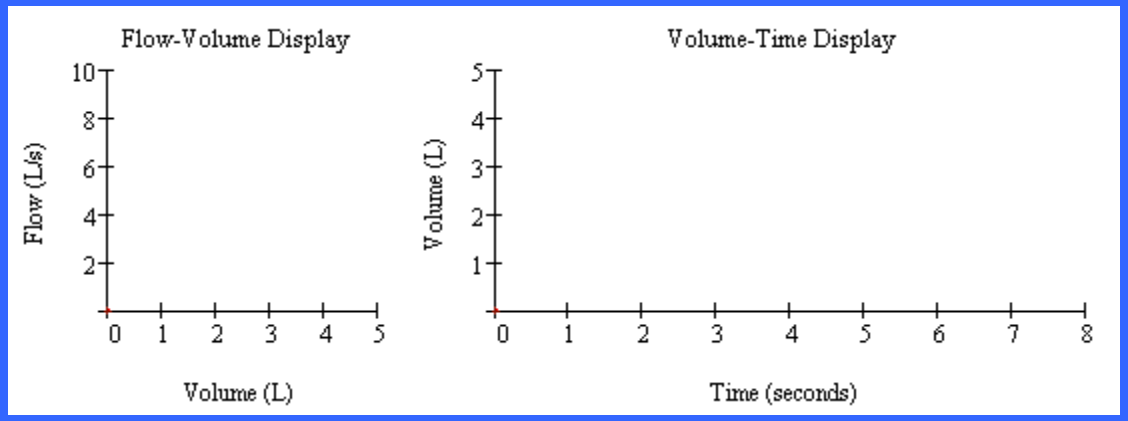
Unacceptable Curve - Abrupt Termination



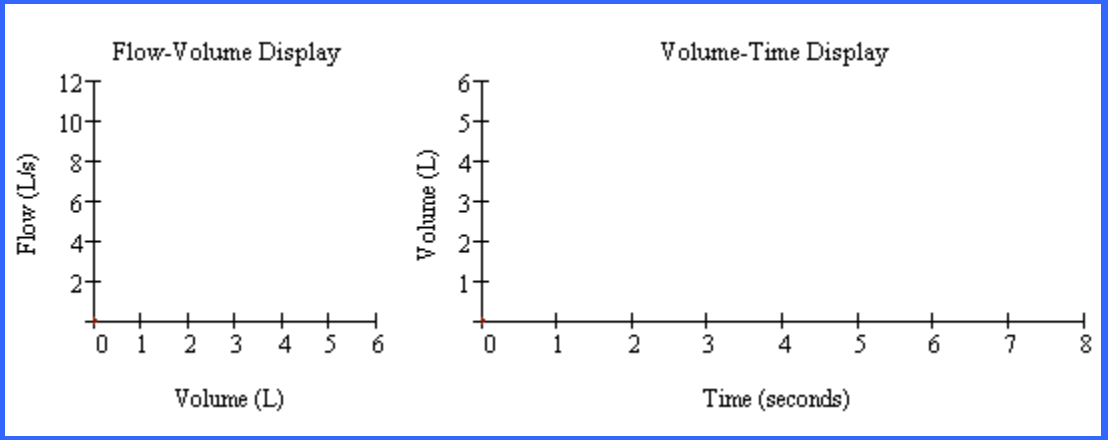
Unacceptable Curve – Leak



Unacceptable Curve – Obstructed Mouthpiece



Unacceptable Curve – Extra Breath



Extra air inhaled through nose, so to prevent **Use a noseclip**

Coach the patient to BLAST out the air !

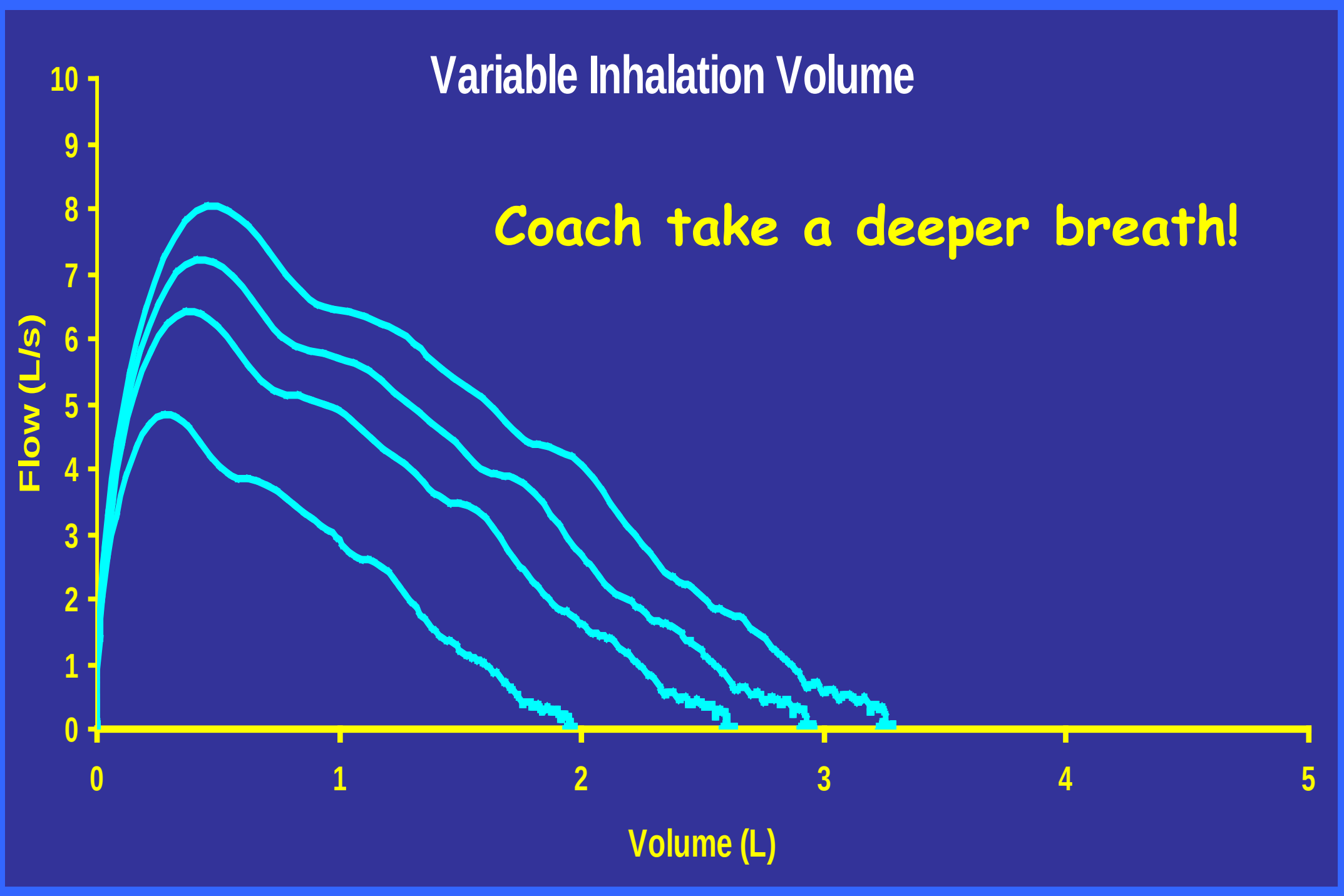
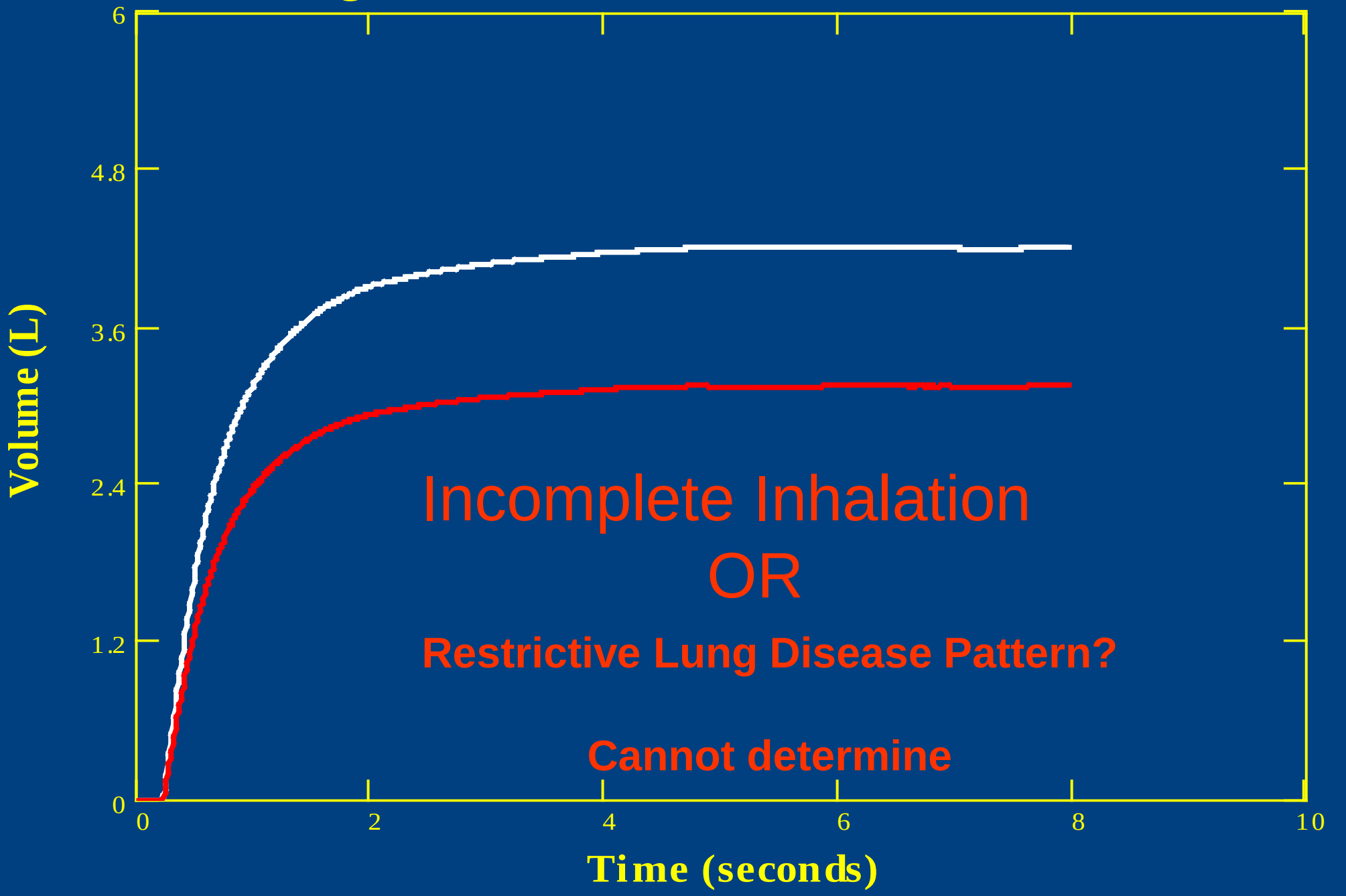
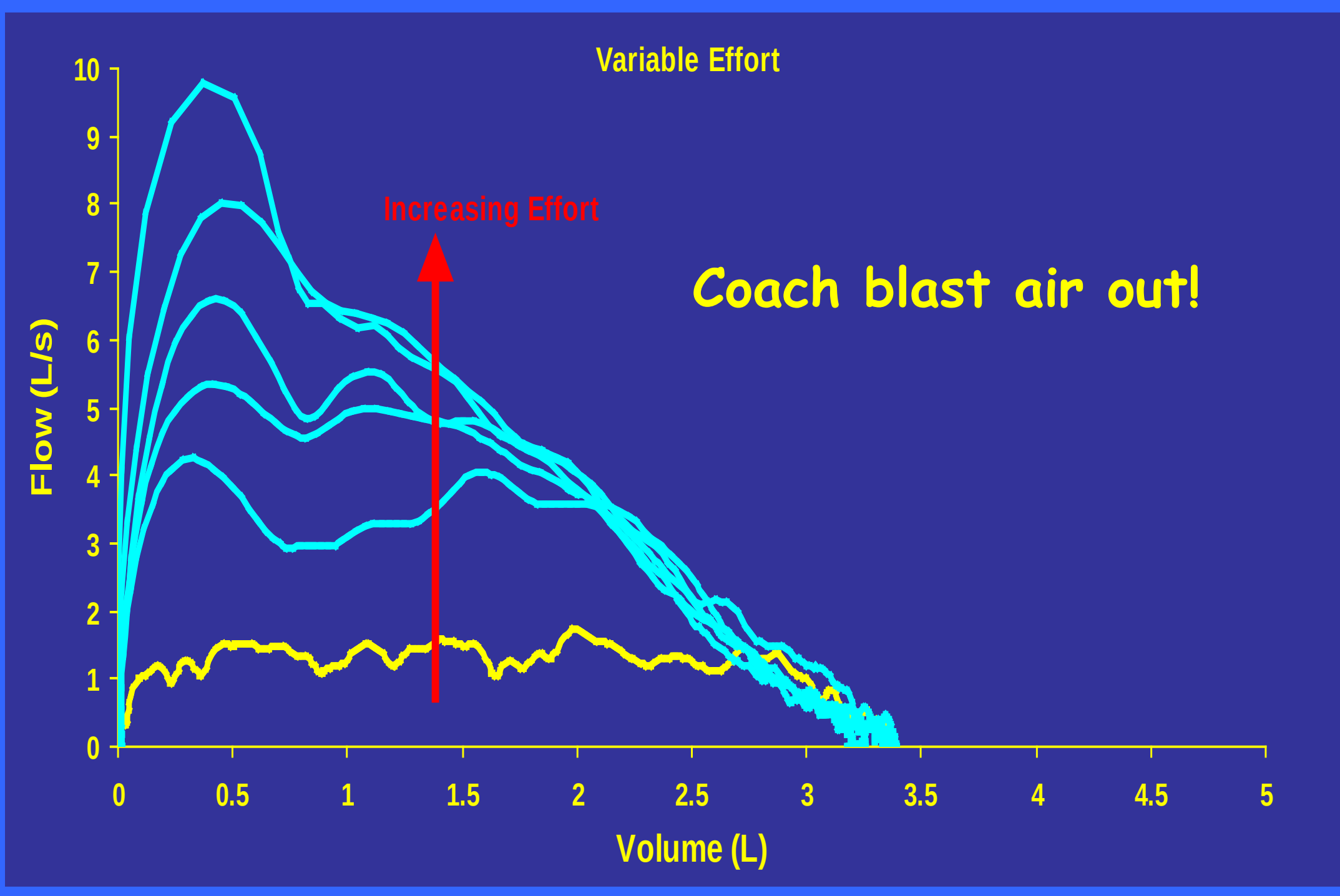

Variable Inhalation Volume
Coach take a deeper breath!
Flow (L/s)
10
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
5
Volume (L)

Figure 2-5 Normal & Restrictive Patterns



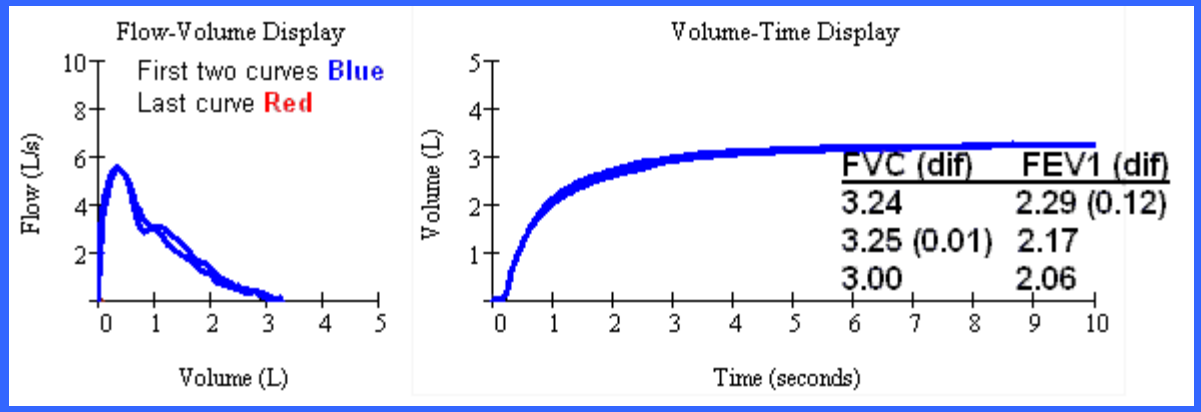

Variable Effort
Increasing Effort
Coach blast air out!
Flow (L/s)
Volume (L)
0
1
2
3
4
5
6
7
8
9
10
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

Reproducibility goals

- Obtain 3 good efforts
- Match FEV1s
  within 0.15 liters
- Match FVC
  within 0.15 liters

Keep testing until you get 3-acceptable maneuvers & reproducible test.
It may sometimes take up to 8 efforts to meet the goal.

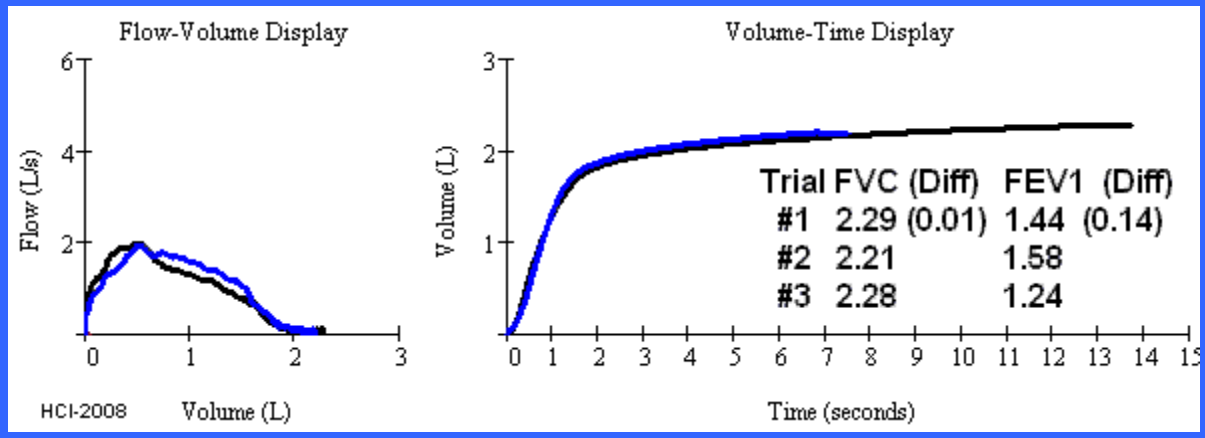
Repeatable Test both FVC and FEV_1 differences < 0.15 L



Goal – 3 acceptable curves and largest and second largest FVC within 150 milliliters and largest and second largest FEV_1 within 150 milliliters.

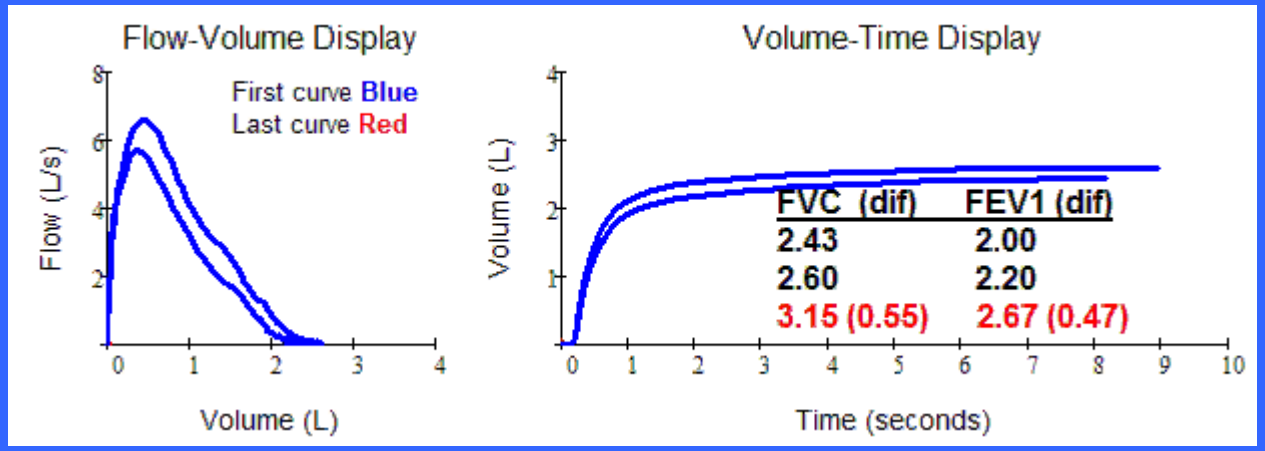
Examples of Test Repeatability

Goal – 3 acceptable curves and largest and second largest FVC within 150 milliliters and largest and second largest FEV_1 within 150 milliliters.



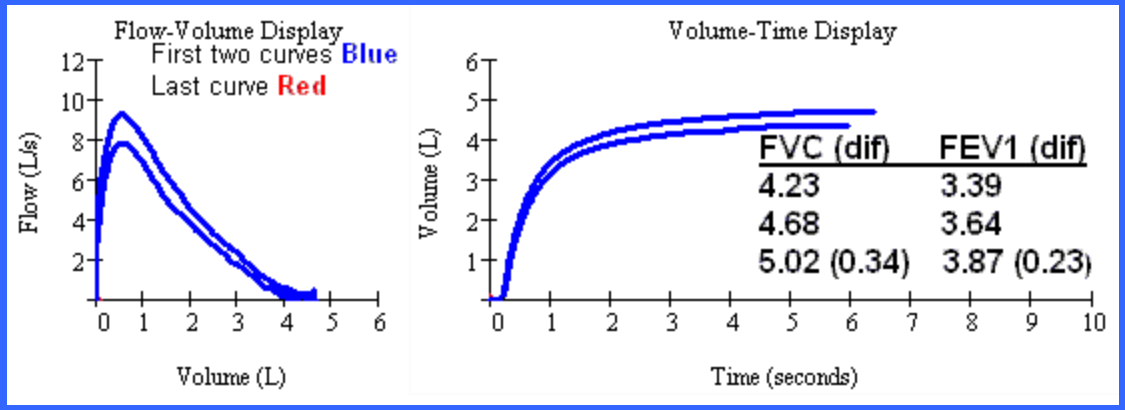
The test above is repeatable but does NOT have 3-acceptable curves due to poor effort (peak flow of 2 liters/sec should be twice FVC or 4 liters/sec).

Non-Repeatable Test – Large differences in Red



Coach take in a deeper breath

Non-Repeatable Test – Smaller differences but NOT repeatable



Spirometry Quality: Factors that affect it

- The technologist
- The patient
- The spirometer
- The interpretation

Components of the spirometry QA program

1. Enthusiastic, happy, trained technologists
2. An accurate, easy to use spirometer
3. Test session quality checks and messages
4. Central review and reporting of quality

Test session quality grades

A	3+ acceptable, 2 match within 0.10 L (6s + Plat)
B	2+ acceptable, 2 match within 0.15 L (6s + Plat)
C	2+ acceptable, 2 match within 0.20L (6-s)
D	only one acceptable maneuver
F	no acceptable maneuvers

Spirometry test session quality grades indicate the degree of confidence that should be placed in the results. The grades are printed on the spirometry reports.

How to get A or B quality grades > 90% of the time

1. Gain rapport and demonstrate the athletic-like breathing maneuvers.
2. Closely observe the subject's body language throughout the maneuvers.
3. Follow the maneuver quality messages and again demonstrate how to do it correctly.
4. After a rest, obtain more maneuvers

How to obtain reproducible results

- When you see: “Take a deeper breath…”
- Use your body language during the demo
- Coach enthusiastically for deeep inhalations:
  - On (your) tiptoes
  - Eyes wide open
  - Shoulders back
  - Palms up with hands moving upwards

Calibration Checks

- Use a 3.00 liter syringe
  to verify accuracy within 3% daily
- Do a leak check daily

Summary

- Submaximal breathing efforts frequently cause both falsely positive and falsely negative results.
- Submaximal inhalations falsely reduce all the numbers.
- Submaximal efforts may mimic asthma, COPD, or restriction.
- Short efforts may mimic restriction or obscure obstruction.
- The spirometry software grades test session quality, but may miss poor efforts and introduce errors.
- The spirometry technician is responsible for detecting and correcting all of the above problems.

Quality Reports from RC

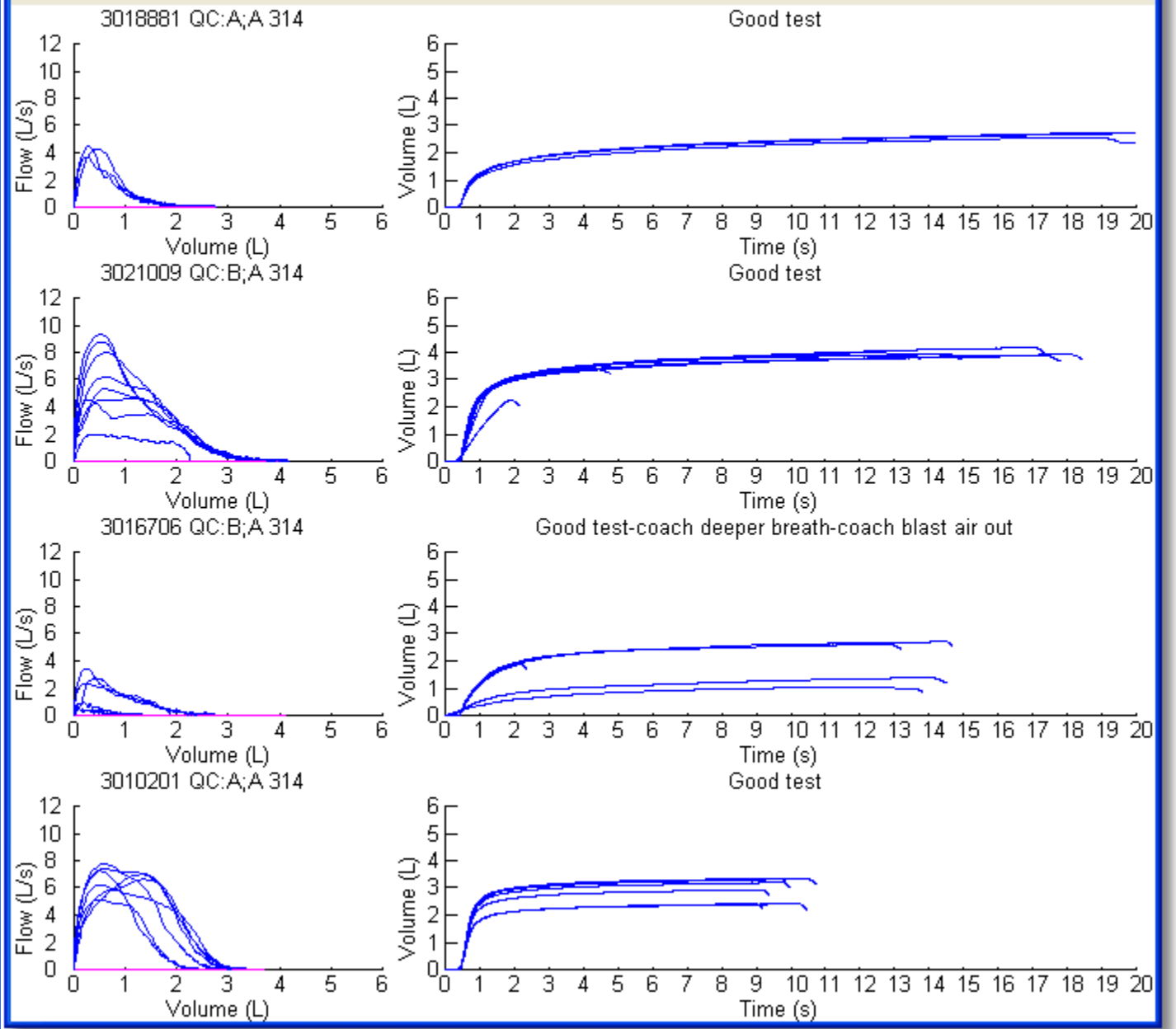
- Calculation of FVC & FEV1 quality grades
- Review calibration leak & checks
- Operator reports
- QC report of Quality Grades
- QC summary report
- QC trend report

Operator Report for Operator

OK

Abort

Operator=314



Spirometry Quality Control Report

OK Cancel Help

Calibration Summary

All IDs selected

1051 calibration checks, 925 leak checks
1 (0.1%) syringe calibration check errors
15 (1.6%) leak check errors

Quality Control Summary Report By Operator; A=4

All IDs selected

Operators	Number	NA	QC(FVC)	QC(FEV1)
All Operators	1323	5.20	3.59	3.73
314	17	4.96	3.59	3.76
316	73	5.16	3.52	3.62
357	33	4.31	3.39	3.58
387	8	4.95	3.25	3.25
405	60	6.13	3.78	3.75
430	166	5.97	3.64	3.80
460	28	5.87	3.89	3.75
516	118	4.45	3.33	3.58
523	45	4.39	3.40	3.73
601	118	4.49	3.65	3.84
654	63	4.79	3.84	3.83
705	16	5.29	3.63	3.75
718	39	5.33	3.77	3.69
741	8	4.25	3.88	3.50
742	10	4.34	3.90	3.70
744	54	5.50	3.76	3.89
748	71	5.29	3.03	3.34
750	1	5.13	4.00	4.00
752	61	4.96	3.44	3.72
822	236	5.25	3.67	3.79
865	96	5.86	3.68	3.80
CC	2	4.00	4.00	4.00

Spirometry Quality Control Report

OK Cancel Help

Quality Control Report for All Operators

All IDs selected

1323 Test Analyzed

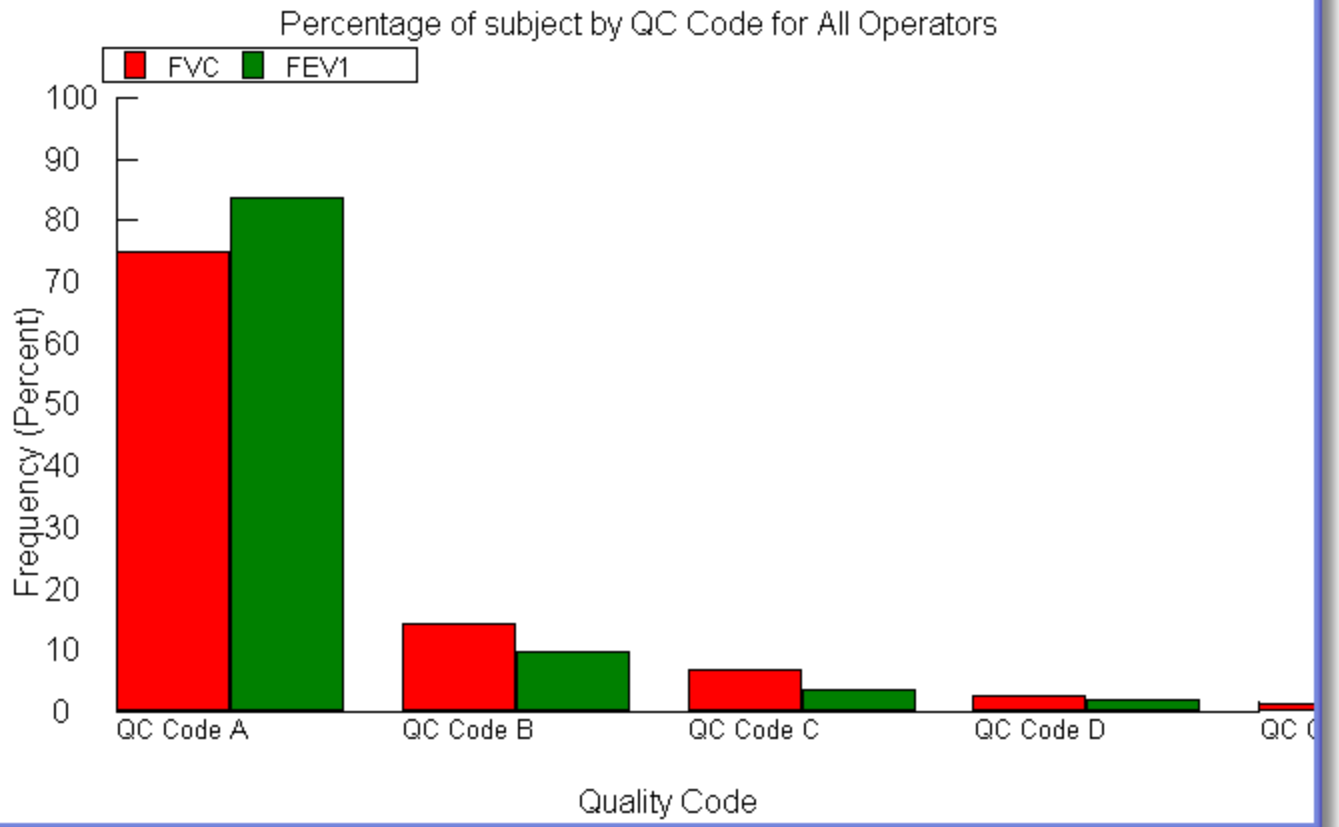
Average number acceptable curves = 5.13

Average FVC QC Code = 3.59 Average FEV1 QC Code = 3.73

Percentage of non-repeatable tests = 9.7%

Percentage of tests with < 3 acceptable curves = 0.8%

Percentage of test with < 2 acceptable curves = 0.5%



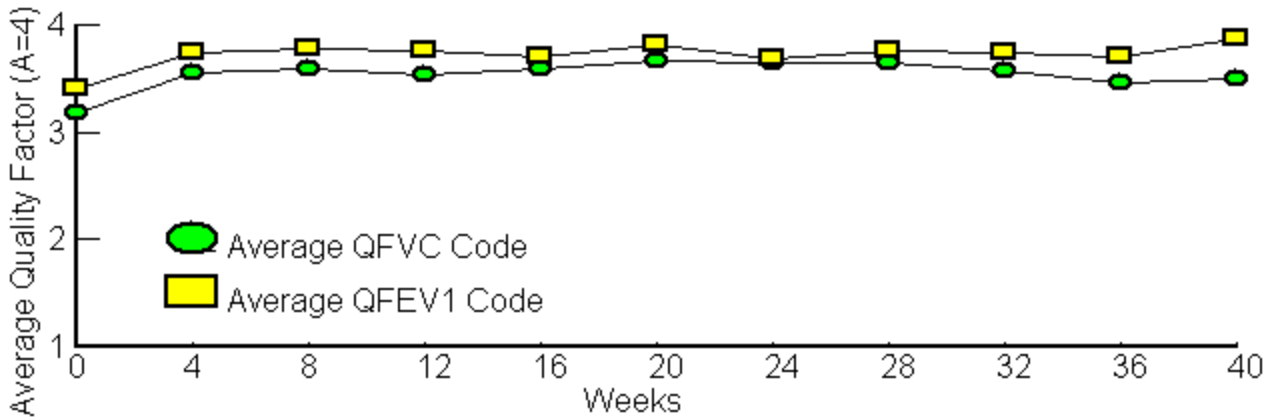
Spirometry Quality Control Report

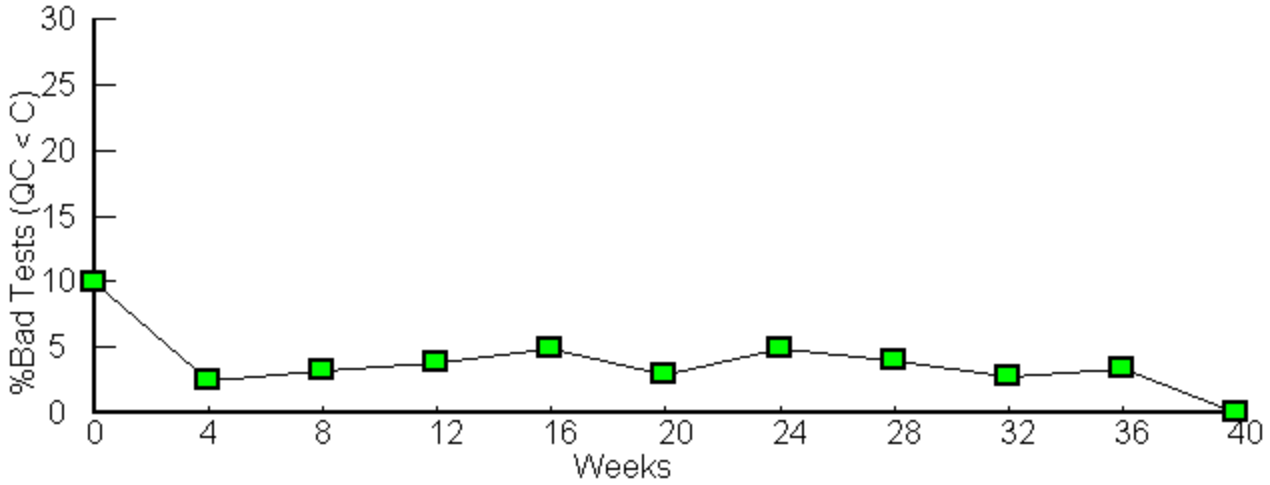
OK Cancel Help

Trend Period 10/01/2004 to 07/22/2005 (40 weeks)

Week	N	QFVC	QFEV1	%Bad	Week	N	QFVC	QFEV1	%Bad	Week	N	QFVC	QFEV1	%Bad
0	132	3.18	3.41	9.8%	4	167	3.55	3.74	2.4%	8	96	3.59	3.77	3.1%
12	129	3.53	3.76	3.9%	16	142	3.58	3.70	4.9%	20	211	3.67	3.81	2.8%
24	228	3.65	3.69	4.8%	28	231	3.65	3.75	3.9%	32	142	3.57	3.73	2.8%
36	88	3.47	3.70	3.4%	40	8	3.50	3.88	0.0%					

QC Code Trends for All Operators; 4=A, 3=B, 2=C, 1=D, 0=F





Questions???