Pulmonary Function Tests

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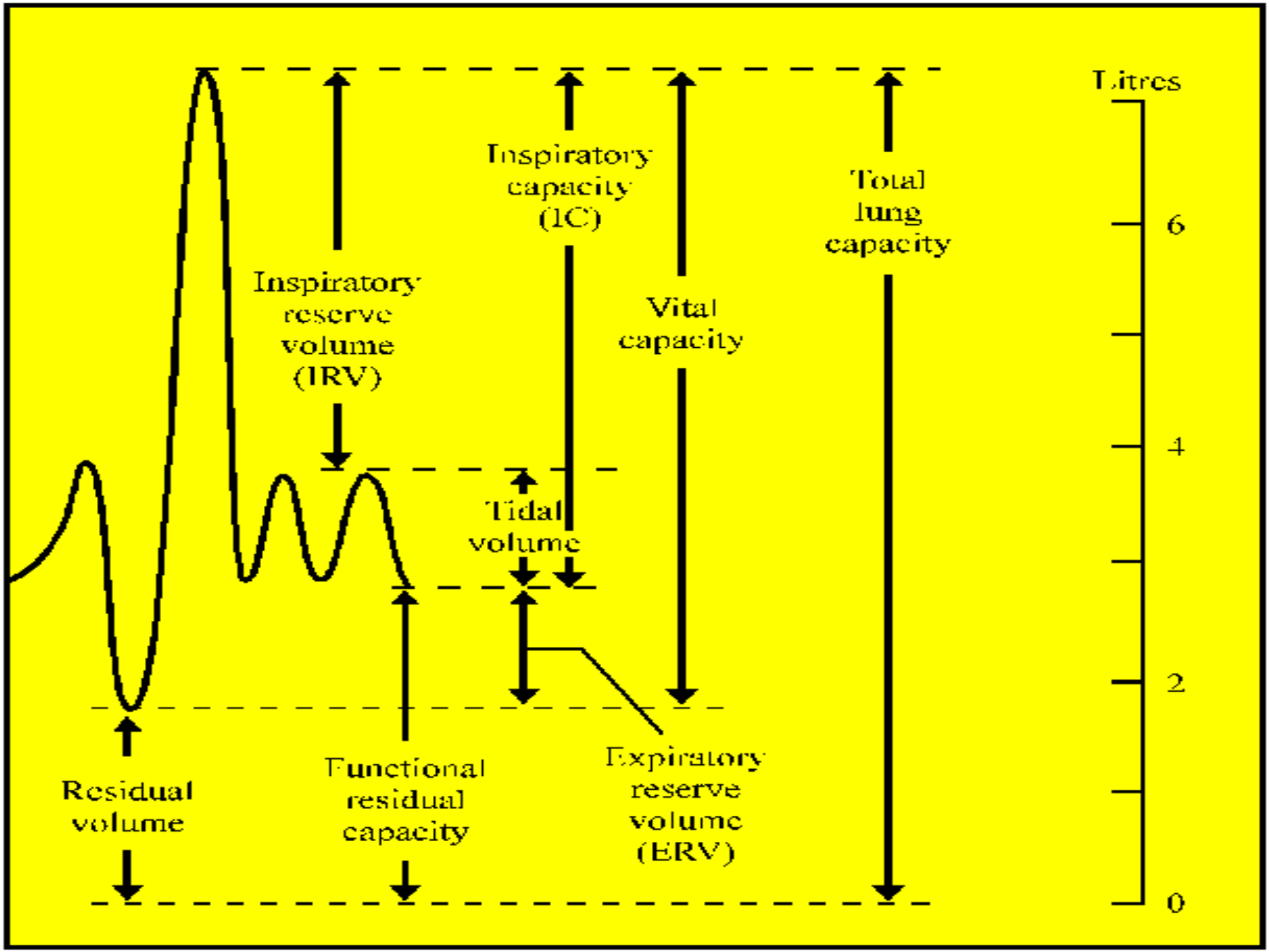
Pulmonary Function Tests

- **Pulmonary Function Tests:**
  - **Spirometry**
  - **Peak-Flow metry**
  - **Bronchoprovocation Tests**
  - **Body Box Plethysmography**
  - **Nitrogen Washout Test**
  - **DLco**

SPIROMETRY

Physiology

- Tidal Volume
- Inspitatory Reserve Volume
- Expiratory Reserve Volume
- Residual Volume
- Vital Capacity
- Total Lung Capacity


Litres
6
4
2
0
Inspiratory capacity (IC)
Total lung capacity
Inspiratory reserve volume (IRV)
Vital capacity
Tidal volume
Residual volume
Functional residual capacity
Expiratory reserve volume (ERV)

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Instrument

- Volume measuring Spirometers
- Flow measuring Spirometers
  - Hot wire cooling
  - IR scattering

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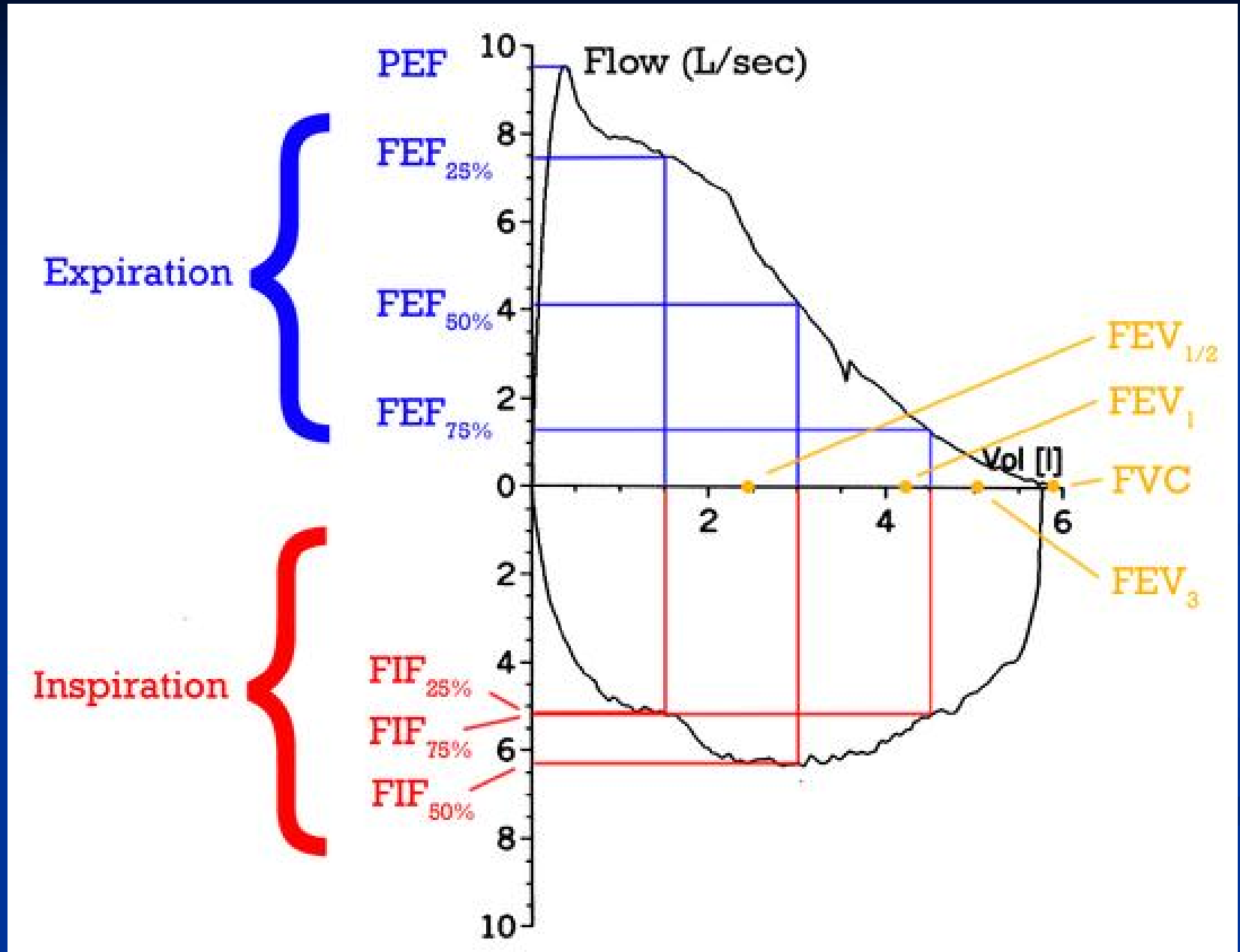
The FVC Maneuver

- Maximal inspiration and then rapidly, forcefully and completely exhale.
- Sitting or Standing.
- Nose clip.
- No hesitation in start of test.
- Patient Instruction is necessary.


Flow (L/sec)
PEF
FEF25%
FEF50%
FEF75%
Expiration
Inspiration
FIF25%
FIF75%
FIF50%
FEV1/2
FEV1
FVC
FEV3
Vol [l]
10
8
6
4
2
0
2
4
6
8
10
2
4
6

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Spirometric Parameters

- Forced Vital Capacity (FVC)
- Forced expiratory Volume in 1st second(FEV1)
- FEV1/FVC
- Peak expiratory flow rate (PEFR)
- Mean expiratory flow during the middle half of FVC (FEF25-75)

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Acceptability of Spirogram

- At least 3 forced expiratory curves that are free from:
  - Interruptions due to coughing, glottis closure or….
  - Hesitant or false start.
  - Inconsistent effort.
  - Early termination.
  - Excessive variability (Two largest FVC or FEV1 should not vary by more than 5%) .

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Acceptability Criteria

- Maximal inspiration at start
- Maximal expiratory effort with no hesitation or false start (VEXT or Back Extrapolated volume<5% of FVC if FVC is more than 3liters or<150ml if FVC less than 3 liters)
- No cough or discontinuity of effort in the first second
- No obstruction of airflow by mouthpiece, tongue, teeth or glottis
- Satisfactory end of effort (Plateau on volume-time curve with<40 ml exhaled over the last 2 seconds or usually at least 6 seconds)
- No leak (e.g., from nose, lips, mouthpiece ,…)

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Reproducibility Criteria

- Largest and second largest FVC within 5% or 100 ml
- Largest and second largest FEV1 within 5% or 100 ml

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Spirometric Tests Interpretation

- **Selecting Predicted Values:**
  - Age, Gender, Race, Height,
- **Setting Lower Limit of Normal (LLN):**
  - 80% of predicted values.
  - 95^{th} percentile method.
  - 95% confidence interval[Predicted value-(1.645*SEE)]

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Selecting Predicted Values:

- Almost 100 published paper about “Reference Value” in the world
- Two published papers in international journals from Iran:
  - Boskabadi (2002)
  - Golshan (2003)
- 3-4 published paper about reference value in Iranian Journal:
  - Kashan
  - Kordestan
  - Yazd
  - sari

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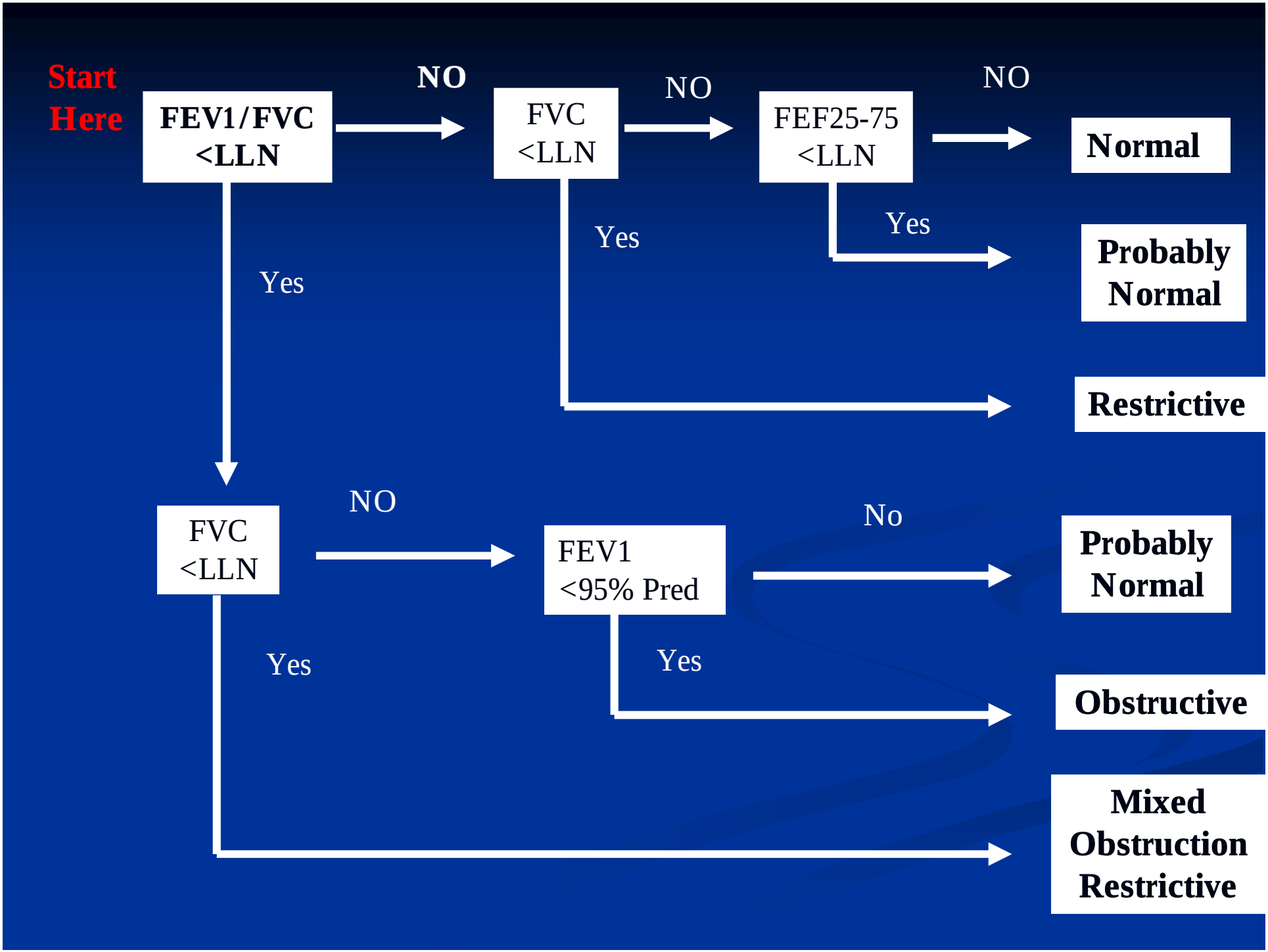
Selecting Predicted Values:

- **ERS/ECCS predicted values for men:**
  - **FVC = 5.76 H -0.026A-4.34 (SEE=0.61)**
  - **FEV1 = 4.30H-0.029A-2.49 (SEE= 0.51)**
- **ERS/ECCS predicted values for women:**
  - **FVC = 4.43 H -0.026A-2.89 (SEE=0.43)**
  - **FEV1 = 3.95H-0.025A-2.60 (SEE= 0.38)**


Start Here
FEV1/FVC <LLN
NO
FVC <LLN
NO
FEF25-75 <LLN
NO
Normal
Yes
Yes
Probably Normal
Yes
Restrictive
FVC <LLN
NO
FEV1 <95% Pred
No
Probably Normal
Yes
Yes
Obstructive
Mixed Obstruction Restrictive

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Spirometric Tests Interpretation

- **Severity of Obstruction:**
  - **Mild:** FEV1>=70%
  - **Moderate:** 60%=<FEV1 <70%
  - **Moderately Severe:** 50%=<FEV1 <60%
  - **Severe:** 34%=<FEV1 <50%
  - **Very Severe:** FEV1<34%

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Spirometric Tests Interpretation

- **Severity of Restriction*:**
  - **Mild:** 70%=<FVC < LLN
  - **Moderate:** 60%=<FVC <70%
  - **Moderately Severe:** 50%=<FVC <60%
  - **Severe:** 34%=<FVC <50%
  - **Very Severe:** FVC <34%

***When TLC is not available.**

LLN = Lower Limit of Normal.

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Reporting

- A testing session may consist of tree to eight acceptable efforts
- Failure to meet acceptability and reproducibility criteria should be noted. The largest FEV1 and the Largest FVC from all acceptable maneuvers should be reported.

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Common Mistakes

- Erroneous measurement of patient's height
- Errors arising from selected reference value
- Early Termination
- Poor Effort (Weak Push) (Inadequate Force)
- Small inspiration
- Poor Start
- Poor reproducibility

Measurement of Real Height

- Use of arm span
- Indication:
  - Kyphoscoliosis
  - Paralytic individuals
  - Lower extremities amputation
- Method:
- Correct measurement of arm span
  - Men: real length= arm span/1.03
  - Women: real length= arm span/1.01

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Analysis of trends: cross sectional vs. longitudinal

- When PFT is measured at regular intervals, the resulting data must be looked as trend of changes besides.
- After age 35 to 40 the annual decline of FEV1 & FVC in adults is about 25 to 30 ml.
- There is an acceleration in the rate of decline with age.

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Analysis of trends: Confounding factors

- PFTs done by different instruments
- PFTs done by different technicians
- PFTs interpreted using different predicted values
- PFTs done at different times of day(up to 5% variation)
- PFTs done when the subject was not healthy enough
- Learning effect

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Analysis of trends

- ATS : A greater than 15% change from year to year has to be considered significant.
- Zenz : A greater than 10% change from year to year has to be considered significant, 15% change is clinically significant.
- When comparing PFTs in longer intervals, be sure to adjust aging effect(30 ml/yr)

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Bronchodilator studies

- It is used to assess reversibility of airway obstruction
- Test to test & day to day variability
- An acute response to B.D correlates with clinical response to B.D or corticosteroid therapy in asthma & COPD

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Bronchodilator studies

- Most laboratories use β-agonists
- The use of a large volume spacer device is recommended
- Commercially available preparations of β-agonists use an alcohol carrier, which may irritate the airways (**Paradoxical bronchospasm**)

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Bronchodilator studies

- The lack of an acute B.D response **does not** rule out the presence of airway hyperresponsiveness
- The lack of an acute B.D response **does not** preclude a beneficial clinical response to B.D therapy
- Significant response may be determined on the basis of change in F-V curve shape, Subjective judgment, the magnitude of change in FEV1(12% with an absolute value>200ml

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Preshift & Postshift testing

- It can demonstrate a significant physiologic change that may be related to workplace.
- Quality control is of paramount importance in performing comparative measurements.
- PFT indices are Max in early morning and Min in early afternoon with an 5% variation.
- A 10% decline in PFT indices during working shift is regarded significant.
- Delayed response to workplace exposures may not be detected by this method.

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Peak Flow measurement

- Follow daily trends in patients.
- Results are expressed as a percentage of the mean value for the 15-day period.
- A greater than 20% change in peak flow is usually considered significant.
- It is useful in detecting a relationship to occupational exposures when coupled with symptoms, use of medications and daily activities.

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Peak Flow measurement

- It is effort dependent.
- The patient should be well trained to be consistent.
- The patient is not blinded to results.
- Peak flow has greater within-person variability than FEV1 and may underestimate the degree of impairment in severe obstructive patients.
- Some patients with severe airway obstruction can have normal peak flows.
- Peak flow can be reduced for reasons other than airway obstruction.

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Peak Flow measurement

- The devices are not indestructible!
- The devices` accuracy may be impaired because of wetness or accumulated dust.
- There is no inexpensive calibration method available.
- Routine periodic replacement of Peakflowmeters is recommended.

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Measurement of absolute lung volumes

- Gas dilution techniques:
  - Helium dilution
  - Nitrogen washout
- Body box plethysmography
- Radiographic techniques

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Gas transfer studies

- **Diffusing capacity measurement evaluates the absorption and excretion gas between the alveoli and the pulmonary capillaries.**
- **DLCO is a function of *Surface area of alveolar membrane , efficiency of alveolar membrane* and *pulmonary capillary bed*.**

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Gas transfer studies

- Confounding factors are:
  - Variations in hemoglobin
  - Variations in carboxyhemoglobin
  - Altitude
  - Body position

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Gas transfer studies

- No consensus regarding indications for measurement of DLCO.
- Valuable screening test and a sensitive indicator of occupational-related interstitial disease.
- Possible indications are: restrictive disorders, obstructive disorders, cardiovascular disorders, other causes of gas exchange impairment and disability evaluation.

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Gas transfer studies

- DLCO is abnormal in restrictive disorders. (useful for diagnosis & long term follow up)
- DLCO is reduced in emphysema & cystic fibrosis.
- DLCO is reduced in thromoembolism, fat embolism, pulmonary hypertension & pulmonary edema.
- DLCO is increased in obesity, asthma, polycythemia, pulmonary hemorrhage, exercise & increased pulmonary capillary bed (e.g. left to right intracardiac shunt) .

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Bronchoprovocation Tests

- **Bronchial Challenge:**
  - **Histamine**
  - **Metacholine**
  - **Cold Air**
  - **Exercise**
- **PC20: The concentration of metacholine causing a 20% drop in FEV1**
- **Normal subjects have a PC20>=8**

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Bronchoprovocation Tests

- **Screening Occupational Asthma:**
  - **In Preplacement Exams for places with known occupational sensitizers.**
  - **The presence of hyperresponsiveness should not be used to exclude worker, repeating test serially may lead to Asthma Dx.**

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Bronchoprovocation Tests

- Diagnosing Occupational Asthma:
  - In subjects with symptoms & FEV1/FVC > LLN