ABNORMAL LUNG FUNCTIONS

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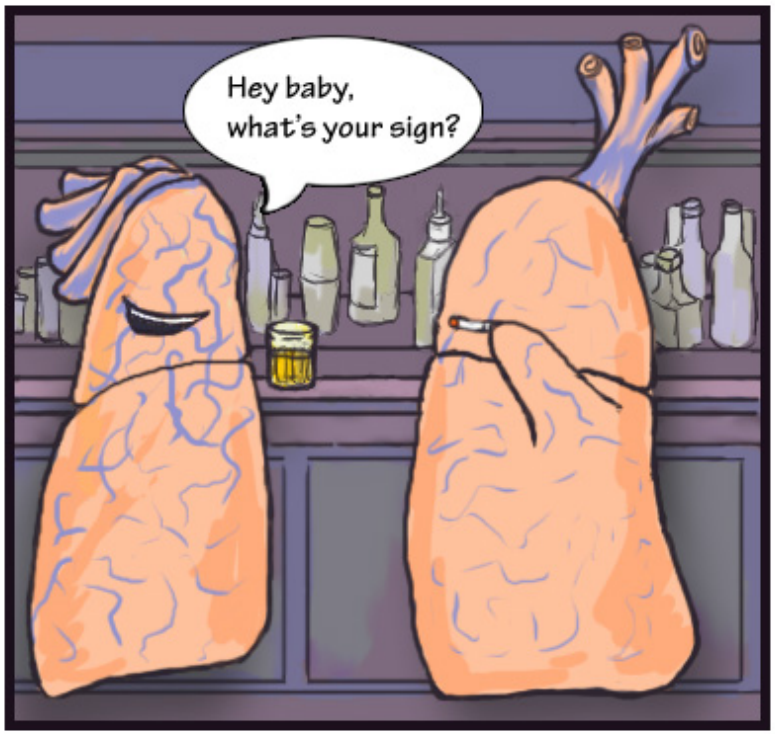
INITIAL EVALUATION FOR LUNG RESECTION

A TRUE CLINICAL PICTURE

- History
  - Functional Capacity
  - Effort Tolerance
  - Smoking
  - Bronchodilator Therapy
- Physical Findings

CLINICAL INDICATIONS FOR PFTS

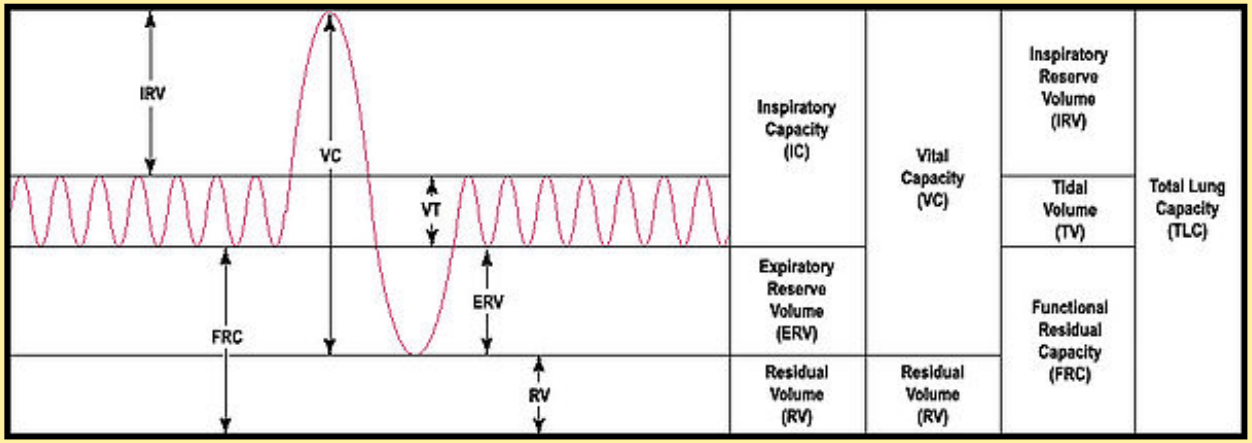
- Diagnosis of a disease process
- Monitoring the response to therapy
- Documentation of the course of a disease process
- **Preoperative assessment for lung resection,** cardiac surgery or non-cardiothoracic surgery
- Evaluation of disability
- Evaluating disease prognosis.

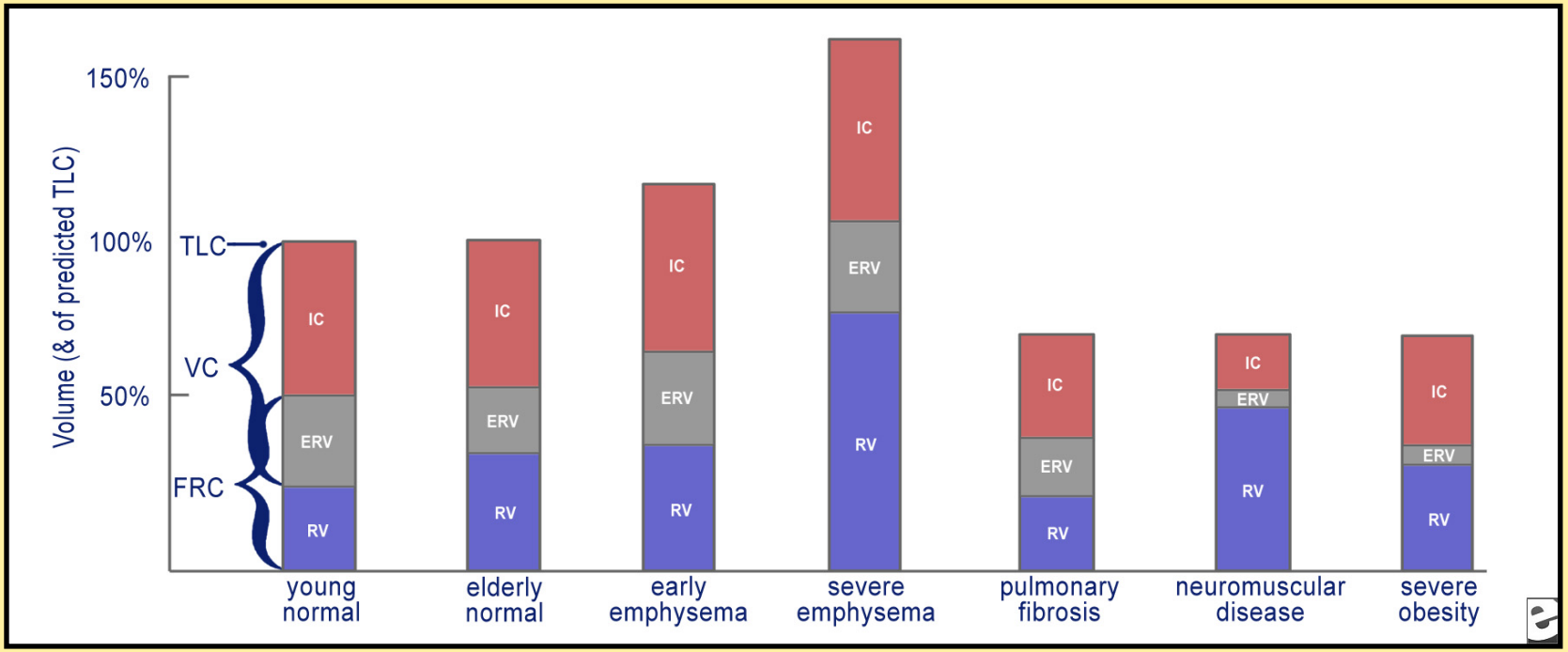


PULMONARY FUNCTION TESTS

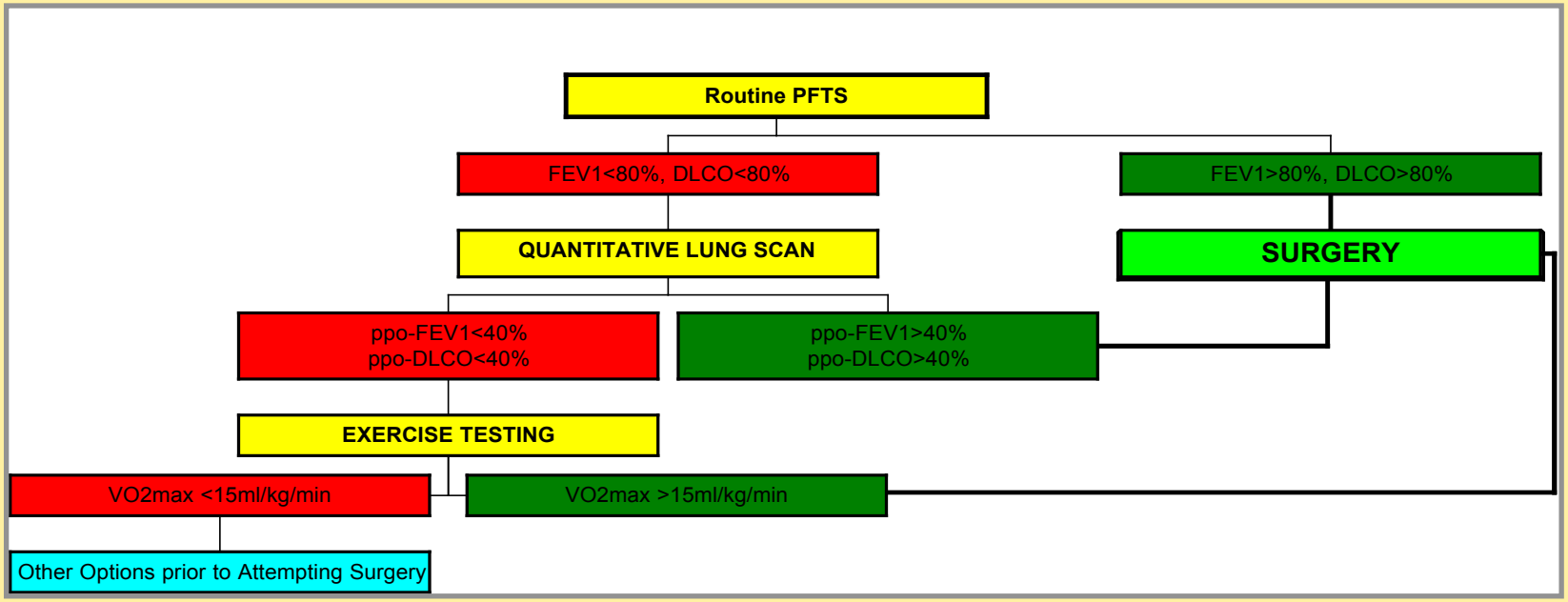
- Assessment of Ventilation
  - Peak flow
  - Spirometry
    - FVC
    - FEV1
    - FEV1/FVC
- Assessment of Gas exchange
  - Transfer factor
  - Arterial Blood Gas &
  - O2 Saturation
- Exercise testing of Cardiopulmonary reserve

LUNG VOLUMES IN DISEASE





STEPWISE APPROACH TO EVALUATION FOR RESECTION

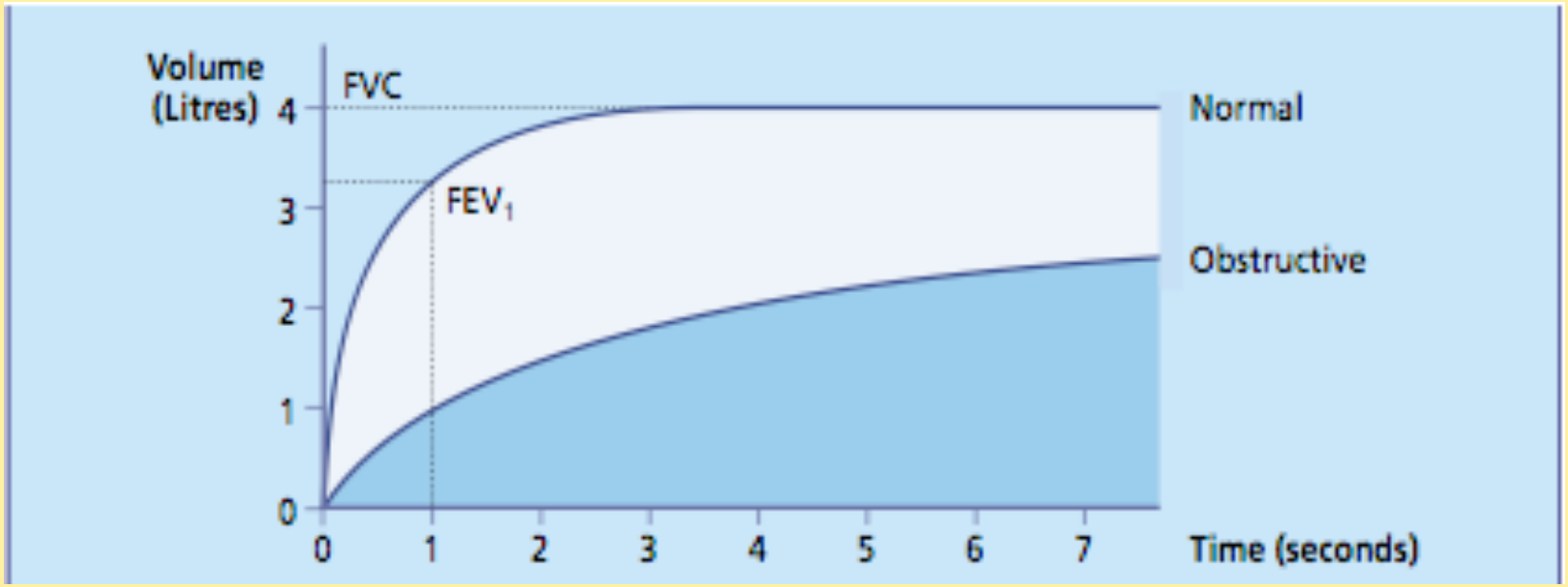


- **Stage I Assessment (Pre-op lung function)**
  - **Spirometry**
  - **Arterial Blood Gas Analysis**
  - **DLCO**
- Stage II Assessment (Post-op lung function)
  - Quantitative Ventilation-Perfusion Scan
  - Quantitative CT Scan
- Stage III Assessment
  - Exercise Testing: Oxygen Uptake (VO2 Max)

SPIROMETRY

- Simple, inexpensive, standardized & readily available
  - FVC = reflect lung volume
  - FEV1, FEF25-75% = reflect airflow
  - MVV = Reflects Muscle Strength
- Predicted depend on
  - age,
  - height,
  - gender and race
    - (Debapriya D et al. CHEST 2003;123:2096-2103)
- Spirometry values provides for Risk Stratification in lung resection
    - (Alfredo et al. ActaBiomed2006;77:69-70)
- ATS recommendation: significant response is an increase of at least 12% and 0.2 L in either FVC or FEV1

Forced Expiratory Volume in 1 second (FEV) and Forced Vital Capacity (FVC)



IDENTIFYING ABNORMALITIES

Identifying abnormalities

Spirometry indicates the presence of an abnormality if any of the following are recorded:

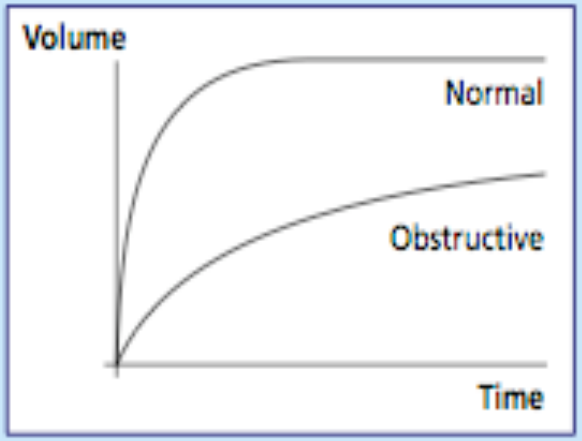
- FEV_1 <80% predicted normal
- FVC <80% predicted normal
- FEV_1/FVC ratio <0.7

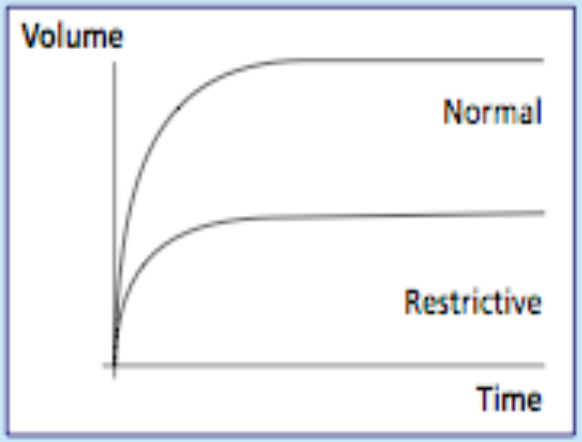
Obstructive disorder:

- FEV_1 reduced (<80% predicted normal)
- FVC is usually reduced but to a lesser extent than FEV_1
- FEV_1/FVC ratio reduced (<0.7)

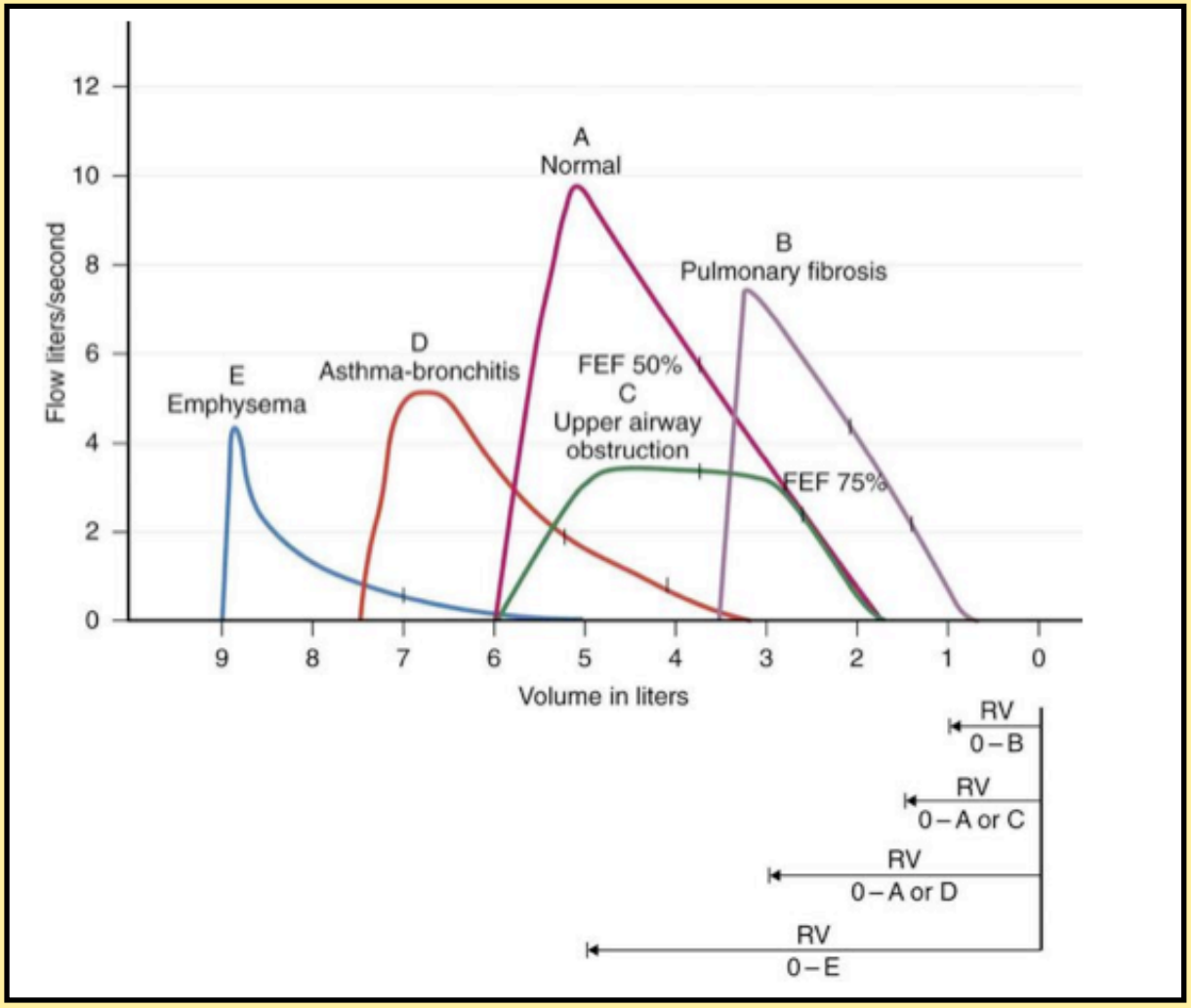
Restrictive disorder:

- FEV_1 reduced (<80% predicted normal)
- FVC reduced (<80% predicted normal)
- FEV_1/FVC ratio normal (>0.7)

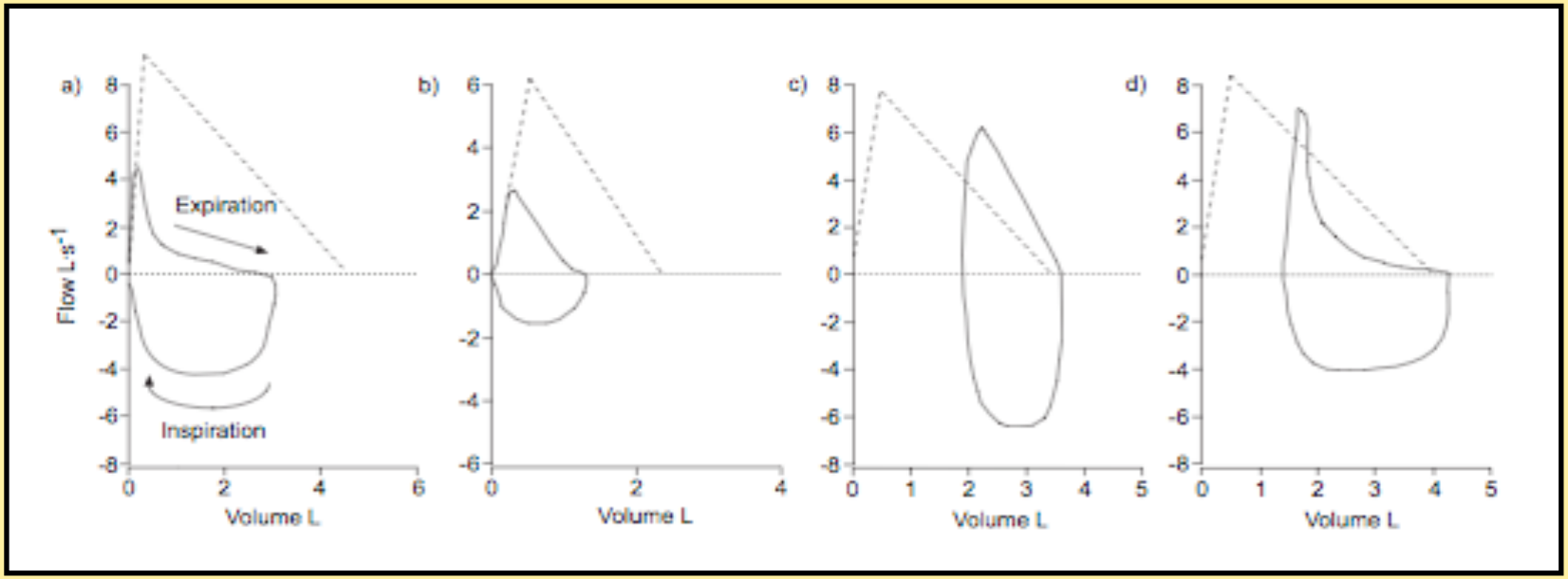




EXPIRATORY FLOW RATES IN DISEASE

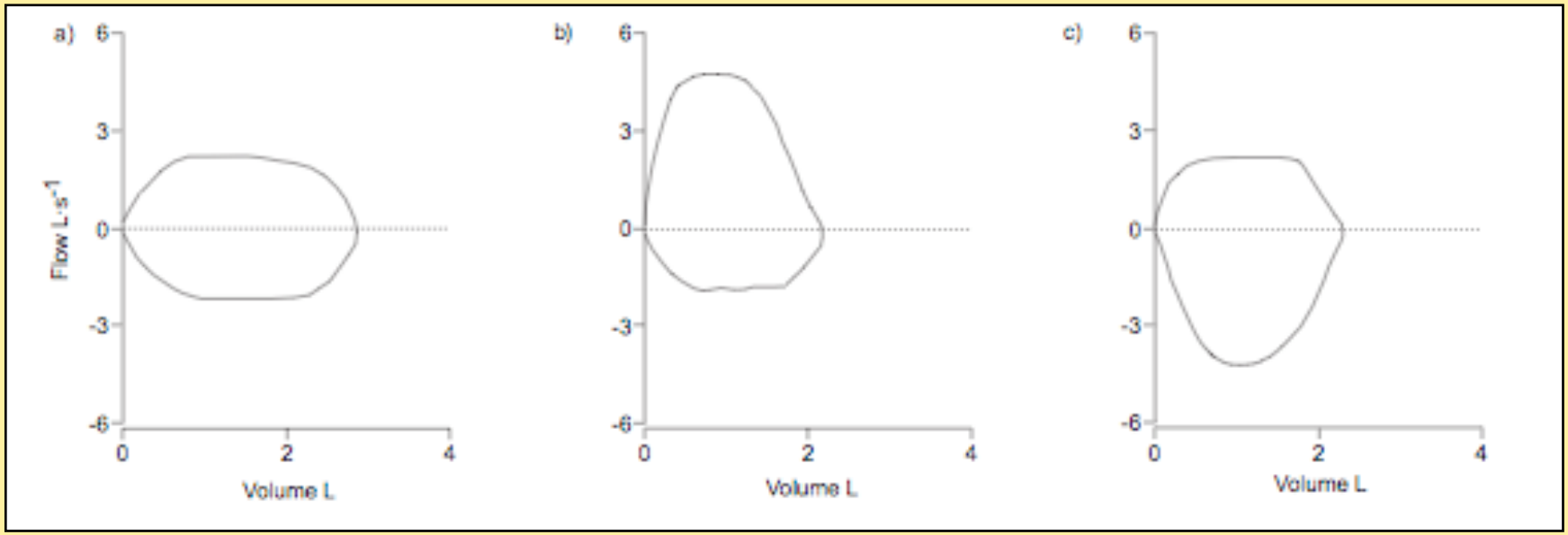


INSPIRATORY AND EXPIRATORY FLOW VOLUME CURVES

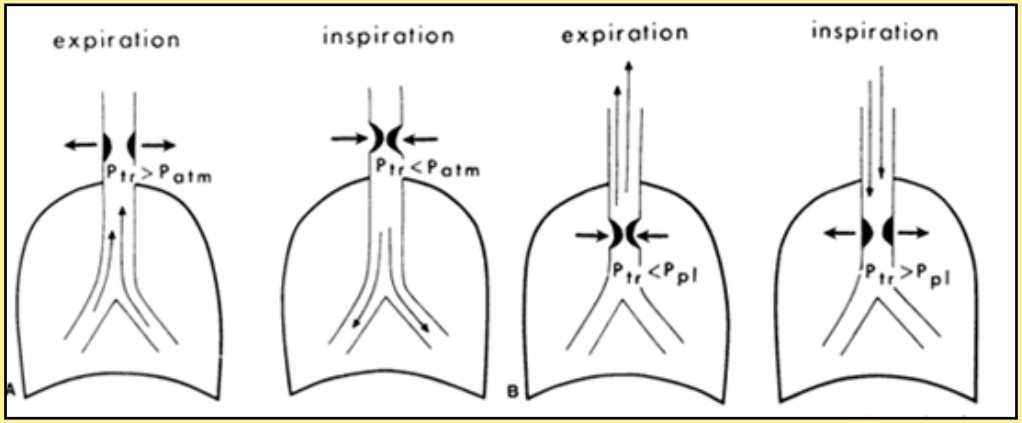


- A) FEV1 = 36%; FEV1 / VC = 46%; PEF = 48%; TLC = 100% (Obstructive)
- B) FEV1 = 57%; FEV1 / VC = 73%; PEF = 43%; TLC = 96% (Obstructive)
- C) FEV1 = 66%; FEV1 / VC = 80%; PEF = 79%; TLC = 62% (Restrictive)
- D) FEV1 = 64%; FEV1 / VC = 64%; PEF = 82%; TLC = 72% (Mixed)

CENTRAL & UPPER AIRWAY OBSTRUCTION



- A) Fixed obstruction
- B) Variable extra-thoracic obstruction
- C) Variable Intra-thoracic obstruction



STAGE I: FEV1

- Pre-op. FEV1 <60% of predicted, Strongest predictor of post-op. complications
- ACCP & BTS Guidelines:
  - FEV1 > 2 L tolerate pneumonectomy
  - FEV1 > 1.5 L tolerate lobectomy

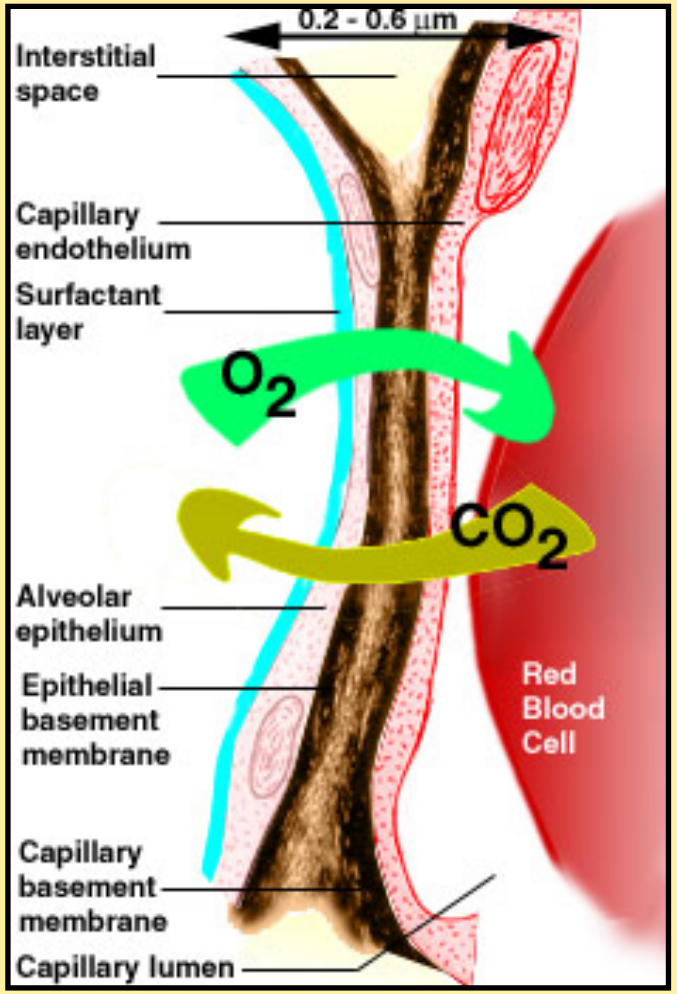
  (*MazzonePJ et al. Am J Med 2005; 118:578-583)*
- Post-op pulmonary complication in patients with
  - FEV1<2L was 40% VS 19% for those with
  - FEV1 >2L
- (*Stephan MK et al. Chest 2000;118:1263-1270)*

STAGE I: FEV1

- BTS Guidelines compiled on data from >2000 patients in 3 large series (1970s) Mortality Rate < 5%
  - FEV1 > 1.5 L for Lobectomy
  - FEV1 > 2 L or > 80% predicted for Pneumonectomy
    - » (*BecklesMA et al., CHEST 2003; 123:105S-114S*)

STAGE I: DLCO

- Alveolar Volume
- Alveolar-capillary membrane integrity
- Pulmonary capillary blood flow
  - Most important predictor of mortality
  - Sole predictor of post-op pulmonary complications (Fergusen et al)
  - Equally significant as FEV1 (*DebapriyaD et al., CHEST 2003;123:2096-2103)*



STAGE I: DLCO

- ACCP guideline for DLCO
  - FEV1>80% but:
    - Undue dyspnoea
    - Interstitial lung disease
- Routine measurement of DLCO for lung resection, irrespective of FEV1 value, improves surgical risk stratification
  (Brunelli A et al., EurJ Cardiothoracic Surg2006;29;567-70)
- Predicted DLCO < 60% associated with "mortality
- DLCO <80% 2-3 fold increased complications
  (Ferguson et al)
- DLCO & FEV1 are complementary physiologic tests
  (BecklesMA et al., CHEST 2003; 123:105S-114S)

ARTERIAL BLOOD GAS ANALYSIS

- Little evidence as predictor of post-op complication
- PCO_2 >45 mm Hg(6.0kPa)
  - Traditional relative contraindication to lung resection
  - But recent studies: PCO_2 > 45 mm Hg (6kPa) did well post-op
  - Not predictive of postoperative complications *(DebapriyaD et al. CHEST 2003;123:2096-2103)*
- Hypoxemia (SaO_2 < 90%) associated with "risk of postoperative complications *(Kearney DJ et al., Chest 1994;105:753-759)*

RECOMMENDATIONS

- Spirometry recommended pre-resection
- Pneumonectomy
  - FEV1 >2 L or 80% predicted
- Lobectomy
  - FEV1 >1.5 L,
- Segmentectomy or Wedge Resection
  - FEV1 >0.6 L,

(Gene L 2007 Chest)

RISK OF MORBIDITY AND MORTALITY

- Pneumonectomy:
  - **FEV1 <2L or 80% of predicted ,**
  - MVV < 55% of predicted
  - **DLCO <50% of predicted ,**
  - FEF25-75% < 1.6L/s.
- Lobectomy:
  - **FEV1 <1.5 L ,**
  - MVV <40% of predicted
  - FEF25-75% <0.6 L/s,
  - **DLCO <50% of predicted.**
- Wedge resection/Segmentectomy:
  - **FEV1 <0.6 L ,**
  - **DLCO <50% of predicted.**

(Stephan F et al., Chest 2000; 118:1263-1270)

CONCLUSION

- Patients should undergo evaluation for surgical resectability
- Patients with FEV1 and DLco>80% of predicted can be referred for surgery without undergoing other tests
- Patients with pre-op.FEV1and DLco<80% of predicted need further evaluation
- Quantitative V/Q lung scan is done estimate PPO FEV1 and DLco

Assessment Cardio-Pulmonary Exercise Testing

- Indicated when PPO FEV1<35 to 40% and DLCO <40% of predicted
- Stresses the entire cardiopulmonary & oxygen delivery system
- Provides a good estimate of cardiopulmonary reserve
- Pulmonary/cardiac function & peripheral oxygen utilization

- Measurement of exhaled gases
  - Oxygen uptake (Vo2)
  - Maximal Vo2 (Vo2max)
- Formula for estimating Vo2
- Predicted Vo2=5.8xwt.in kg+151+10.1 (W of workload)

- VO2max With increasing muscular work VO2 rises to a point where there is a plateau of the VO2 work rate slope.
- VO2 max is a measure of aerobic capacity of the peripheral tissue (Oxygen Consumption)

  (MazzonePJ et al., Am J Med 2005; 118:578-583)

EXERCISE TESTING

- 3 major types of tests
  - Fixed exercise challenge(Sustained level of work)
  - Incremental exercise challenge (Work rate is sequentially increased to a desired end point)
  - Submaximal vs. Maximal oxygen consumption (VO2 Max)
    - *(DebapriyaD et al., CHEST 2003;123:2096-2103)*

Fixed Challenge Exercise Testing

- Fixed Challenge Exercise Testing
  - Climbing a certain number of stairs
  - Walking a fixed distance
- Patients who able to climb up to three floor (i.e. 75 steps) had low number of postoperative complications
  - (*Olsen GN et al., Chest 1991; 99:587–590)*
- Prospective study of 16 patients 6-min walk distance > 1000 feet & Stair climb of > 44 steps, Successful surgical outcome
  - (*Holden DA et al., Chest 1992; 102:1774–1779)*

Fixed Challenge Exercise Testing

- Prospectively evaluated of 83 patients, complications occurred
  - Who unable to climb one floor-89%
  - Who unable to climb two floor-80%
  - Inability to climb 5 floor-32%
  - Who could climb 7 floor-No complications
    - *(GirishM et al. Chest 2001;120:1147-1151)*

Incremental Exercise Testing

- Measurement VO2 max in patients for lung resection
  - VO2 Max > 1 L/min -No mortality
  - VO2 Max < 1 L/min -100% mortality
    - *(Eugene Jet al., SurgForum 1982; 33:260–262)*
  - Incidence of Postoperative complications
    - VO2 Max < 15 mL/kg/min -100% complication rate
    - VO2 Max 15-20 mL/kg/min -66% complication rate
    - VO2 Max > 20 mL/kg/min -10% complication rate
      - *(Smith TP et al., Am Rev RespirDis1984; 129:730–734)*

Indications for Pulmonary Resection

- Neoplastic Disease
  - Primary
  - Metastatic
- Bullous Lung Disease:
  - LVRS
- Diagnosis & Management of inflammatory conditions
  - Granulomas
  - Pulmonary infiltrates
  - Resection of segments destroyed by bronchiectasis

CONCLUSION

- If the PPO FEV1 and DLcoare 40% of predicted, surgical risk is acceptable
- Patients with PPO FEV1 and DLco<40% should undergo exercise testing to evaluate pulmonary reserve and to assess the adequacy of oxygen transport
- Cycle ergometry with incremental workloads, which can measures Vo2, Vo2max

CONCLUSION

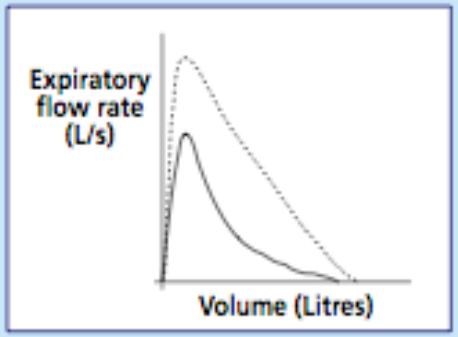
- Patients with Vo2max <10 ml/kg/min. should not undergo lung resection surgery
- Patients with PPO FEV1/ DLco < 40% of predicted, but Vo2max > 15 mL/kg/min, can undergo surgical resection, including pneumonectomy

ABNORMAL FLOW-VOLUME CURVE

Identifying abnormalities with flow-volume curves

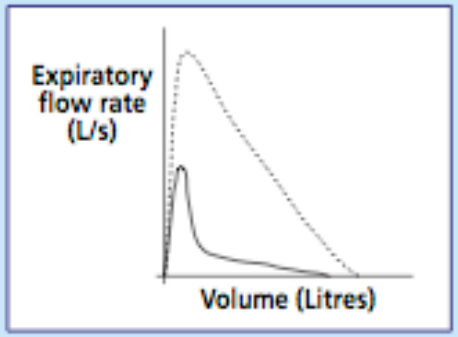
Obstructive disorder:

In this example of a patient with obstructive airways disease, the peak expiratory flow (PEF) is reduced and the decline in airflow to complete exhalation follows a distinctive dipping (or concave) curve.



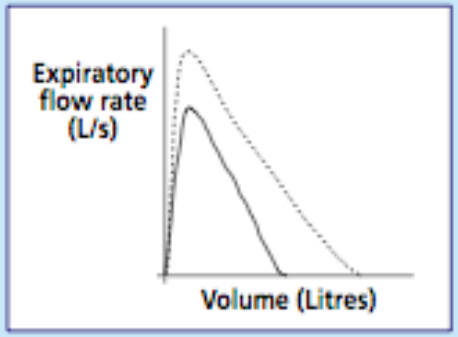
Severe obstructive disorder:

In a severe airflow obstruction, particularly with emphysema, the characteristic 'steeple pattern' is seen in the expiratory flow trace.



Restrictive disorder:

The pattern observed in the expiratory trace of a patient with restrictive defect is normal in shape but there is an absolute reduction in volume.



FLOW VOLUME LOOPS IN DISEASE