PULMONARY FUNCTION TEST IN PRE ANAESTHETIC EVALUATION

It is a complete evaluation of the respiratory system including history from the patients, clinical examination, evaluation of chest x-ray &tests of pulmonary function. It provides objective standardized measurements for assessing the presence and severity of respiratory dysfunction.

The pulmonary function tests are of 2 types.

1. Those that relate to the mechanical ventilatory function of the lungs and the chest wall.
2. Those that detect the abnormalities of gas exchange.

The cornerstone of all pulmonary function testing is of course clinical spirometry. The management considerations are anaesthetic management, the risk of postoperative morbidity and resectability of lung tissue.

THE IDEAL LUNG

1. The lungs must get sufficient oxygen to oxygenate the blood.
2. The lungs must eliminate corbondioxide from the body.
3. The patient must be able to significantly increase their respiratory minute volume to compensate for factors such as increased postoperative metabolic rate , raised body temperature, possible infections such as pneumonia. The inability may result in respiratory failure.

PATIENTS REQUIRING PFT

1. Patients with chronic pulmonary disease.
2. Smokers.
3. Patients with dyspnoea on exertion[non cardiac]
4. Patients with chest wall& spinal deformities
5. Morbidly obese patients
6. Age more than 70 years
7. Patients undergoing upper abdominal surgeries
8. Patients undergoing thoracic surgeries.
9. Presence of respiratory symptoms such as cough and wheeze.

CONTRAINDICATIONS FOR PFT

1. Myocardial infarction within a month
2. Unstable angina
3. Recent thoraco abdominal surgery
4. Recent ophthalmic surgery
5. Thoracic or abdominal aneurysm
6. Pnemothorax

PURPOSE OF PULMONARY FUNCTION TEST

It is to determine
1.How much air can move in and out of the lungs
2.How fast the air in the lungs can be moved in and out
3How stiff are the lungs and chest wall-compliance
4.Diffusion characteristics of the membrane through which the gas moves

PULMONARY FUNCTION TESTS

1.SIMPLE BED SIDE TESTS

A. Breath Holding Test

Patient is asked to take a deep breath as much as he can and hold the breath.

Inference Normal-Greater than 25s
Borderline-15-25s
Severe-Less than 15s

B. Match Test

Patient is asked to blow off a match stick from a distance of 15 cm. A person with normal pulmonary reserve will blow off the match stick

C .Tracheal auscultation

If breath sounds are audible for more than 6s,it denotes significant airway Obstruction

D. Able to blow a balloon

E. Spirometry by pocket size microspirometer

SPIROMETRY

Spirometry assesses the integrated mechanical function of the lung, chest wall and respiratory muscles by measuring the total volume of air exhaled from a full lung [TLC] to an empty lung[RV]

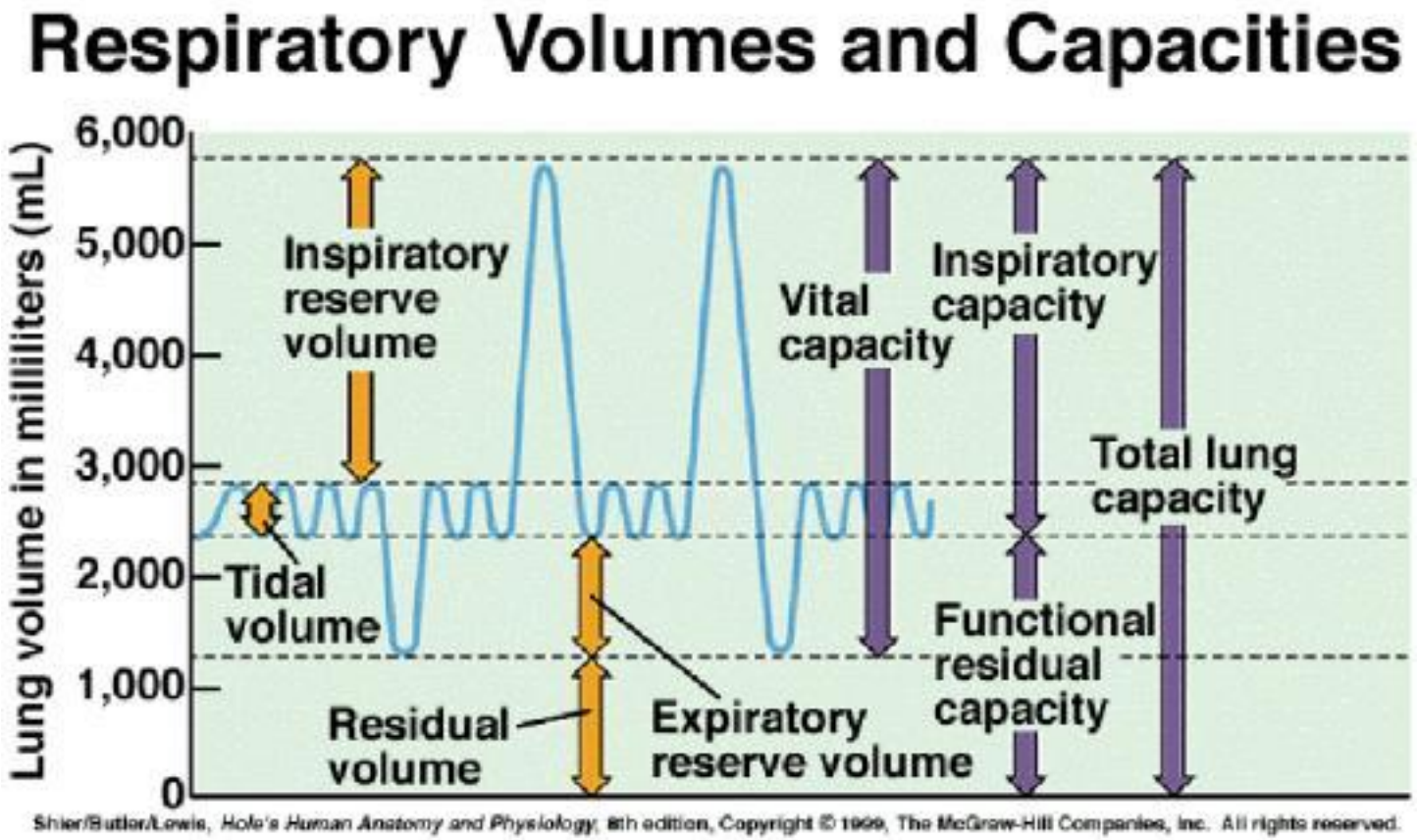
Method of performing the test

Spirometry with flow volume loops assesses the mechanical properties of the respiratory system by measuring the expiratory volumes and flow rates .This test requires the patient to make a maximal inspiratory & expiratory effort. The patient in a sitting position breathes into a mouth piece and nose clips are placed to prevent air leak. It is essential that the patient gives full effort during testing. At least three tests of acceptable effort are performed to ensure reproducibility of results.

It is a versatile test of pulmonary physiology. Reversibility of airways obstruction can be assessed with the use of bronchodilators. After spirometry is completed the patient is given inhaled bronchodilator and the test is repeated. The purpose is to assess whether a patient's pulmonary process is bronchodilator responsive by looking for improvement in the

expired volume &flow rate.A12% increase in FEV1 of at least 200ml on a spirogram performed after bronchodilator therapy is considered to be a significant response.

STANDARD LUNG VOLUMES AND CAPACITIES



TIDAL VOLUME

It is the volume of air moving in and out of the respiratory tract during each ventilatory cycle. Normal value is approximately 500 ml for an adult

INSPIRATORY RESERVE VOLUME

It is the additional volume of air that can be forcibly inhaled following a normal respiration. It is assessed by inspiring to the maximal inspiratory level. Normal value for an adult is approximately 3000ml.

EXPIRATORY RESERVE VOLUME

It is the additional volume of air that can be forcibly exhaled following a normal expiration.It is assessed by expiring to the maximal expiratory level. Normal adult value is approximately 1100ml

VITAL CAPACITY

It is the maximal volume of air that can be forcibly exhaled after a maximal inspiration.
VC=TV+IRV+ERV=4600 ml approximate for an adult

FUNCTIONAL RESIDUAL CAPACITY

It is the volume of air remaining in the lungs at the end of normal expiration. It is approximately 2300ml for an adult.

RESIDUAL VOLUME

It is the volume of air remaining in the lungs after a maximal expiration.It cannot be expired no matter how vigorous or long the effort.
RV=FRC-ERV=1200ml approximately for an adult

TOTAL LUNG CAPACITY

It is the volume of air in the lungs at the end of maximal inspiration
TLC=TV+FRC+IRV=VC+RV=5800ml approximate for an adult

MINUTE VOLUME

It is the volume of air exhaled per minute

MAXIMUM VOLUNTARY VENTILATION

It is the maximum volume of air that can be exhaled by voluntary effort in a 15 s interval .This volume is multiplied by 4& expressed as l/mt

FORCED VITAL CAPACITY

The volume of air that can be maximally forcefully exhaled.

FEV1/FVC is expressed as percentage

FORCED EXPIRATORY FLOW – FEF{25-75}

It is the average forced expirarory flow during the mid portion of FVC

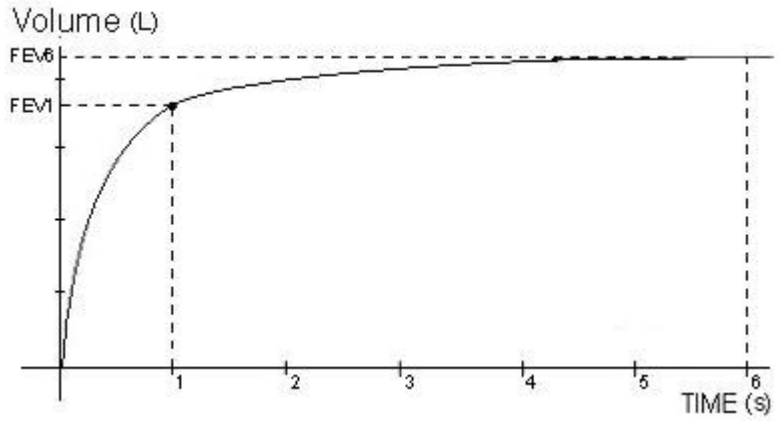
PEAK EXPIRATORY FLOW RATE

It is the peak flow rate during expiration

Spirometry is typically reported in both absolute & as a predicted percentage of normal. Normal values vary,depending on gender, age, race, and height .It is therefore not possible to interpret PFT without such information Hence it is important to ensure that reference formulas in a PFT lab are applicable to the patient population being tested.

OBSTRUCTIVE LUNG DISEASE

Normal spirometry



COPD

It is characterized by the progressive development of airflow obstruction that is not fully reversible .This includes chronic obstructive bronchitis and emphysema

1.FEV1 is decreased-usually less than 65%
2.FEV1/FVC also decreases .Less than 65%denotes high risk
3.FEF {25-75} decreases even more
4.Increased Residual Volume
5.Normal to increased FRC& TLC
6.ABG

Pink puffers- PaO2 greater than 65mm Hg
PaCO2 normal or slightly decreased

Blue Bloaters-PaO2 Less than 65 mm of Hg
PaCO2 grater than 45 mm of Hg

ASTHMA

The forced exhaled volume in one second and the maximum mid expiratory flow rate are direct reflections of the severity of expiratory airflow obstruction

SEVERITY	FEV1 [% predicted]	FEF [%predicted]	PaO2 [mm H g]	PaCO2 [mm Hg]
MILD	65-80	60-75	greater than 60	less than 40
MODERATE	50-64	45-59	greater than 60	less than 45
MARKED	35-49	30-44	less than 60	greater than 50
SEVERE	less than 35	less than 30	less than 60	greater than 50

BRONCHOPROVOCATION TEST

When the baseline spirogram is relatively normal, inhalational challenge may be performed by aerolizing progressive concentrations of methacoline by a dosimeter. This is typically performed as a 5 stage procedure with 5 different increasing concentrations. After each stage, the patient performs spirometry. When there is 20% reduction in the FEV1, the test is terminated and is considered positive for airway hyper reactivity. The provocation concentration dosage level of the inhalational agent required to produce a 20% reduction in FEV1 is labeled PC20FEV1.If the drop in FEV1 is less than 20% after 5 stages , the challenge test is considered negative for airway hyper reactivity. A positive test strongly suggests asthma. False positives can occur with COPD, CCF, allergic rhinitis etc..

RESTRICTIVE AIRWAY DISEASE

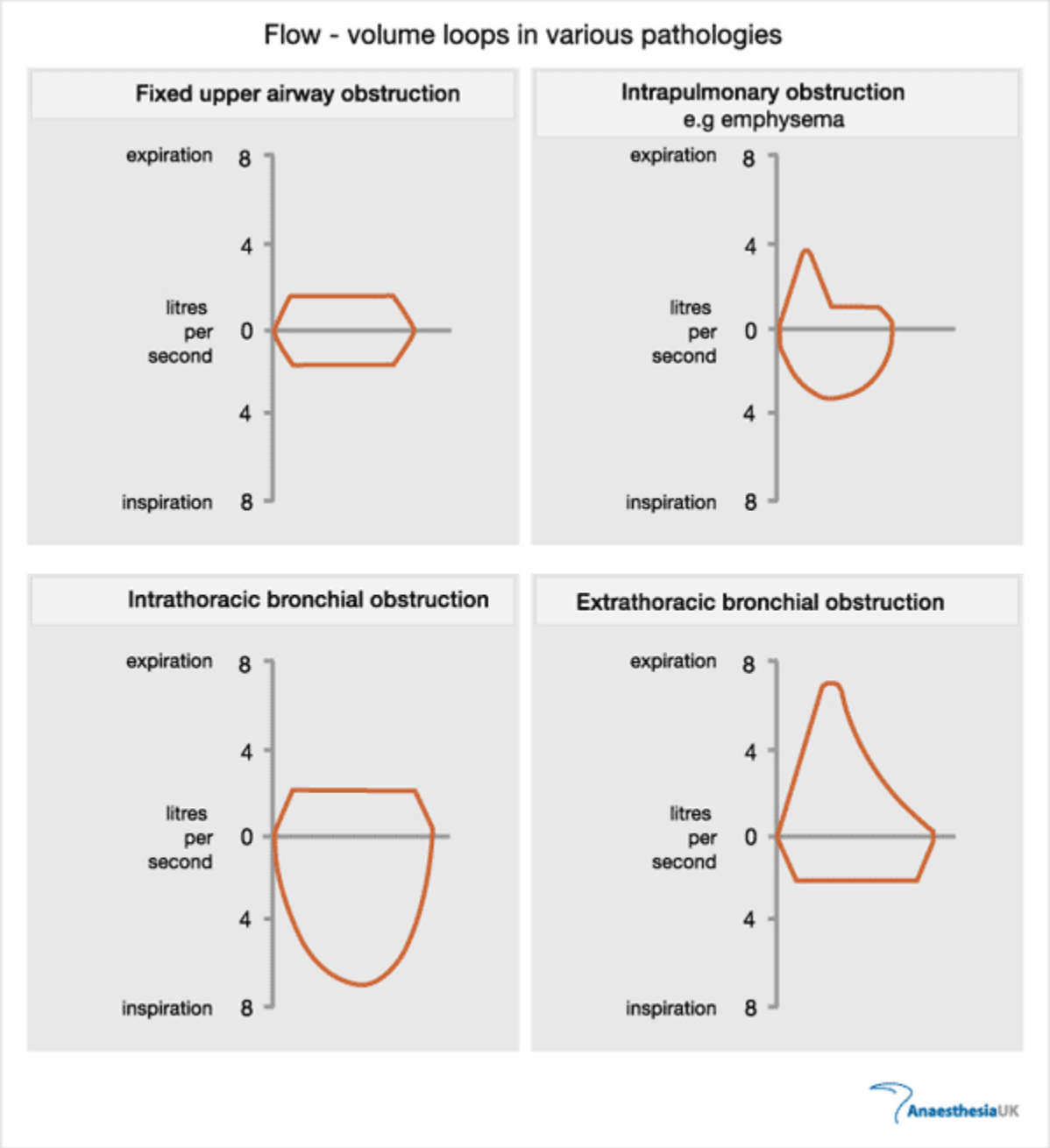
FEV1 is reduced but FEV1/FVC is normal or increased[typically greater than 80%] with a reduction in both FEV1 & FVC

A reduced FVC together with a low FEV1/FVC ratio may occur as a feature of a mixed ventilatory defect in which a combination of both obstructive & restrictive types co exist

APPLICATION OF STATIC LUNG VOLUMES.

Restriction is seen with decreased compliance of lungs [pulmonary fibrosis] or chest wall [kyphoscoliosis]. This results in a uniform reduction in TLC,RV&VC

Over inflation is seen with airway narrowing, either extrinsic due to loss of elastic support as in emphysema or intrinsic due to disease directly affecting the airway wall such as in asthma. These conditions are usually associated with an increase in TLC and a disproportionate increase in RV & FRC so that VC&IC are decreased. In mixed restrictive and obstructive patterns and in respiratory muscle weakness affecting both inspiratory and expiratory muscles, the TLC decreases, the RV increases decreasing the VC



A .Variable intrathoracic obstruction

It is produced by localized tumors of the lower trachea or main stem bronchus, tracheomalacia , & airway changes associated with polychondritis. In these obstructions, there is reduction of airflow during forced expiration with preservation of a normal inspiratory flow configuration. This is observed as a plateau across a broad volume range on the expired limb of

the flow-volume curve. The extra luminal pressure exceeds intra luminal pressure during expiration resulting in airway narrowing

B .Variable extra thoracic obstruction

It is characterized by reduction of inspired floes during forced inspirations with preservation of expiratory flows. The causes are unilateral and bilateral vocal cord paralysis, vocal cord adhesions, vocal cord constriction, laryngeal edema and obstructive sleep apnea

C.Fixed upper airway obstruction

It is characterized by plateaus of flow during both forced inspiration & expiration. The causes include goiters, endotracheal neoplasms, stenosis of both main bronchi, post intubation stenosis & performance of the test through a tracheostomy tube or other fixed orifice device.

Measurement of lung volumes

It can be measured with the use of whole body plethysmography, nitrogen wash out or helium dilution.

Body plethysmography

The patient sits inside an airtight box, inhales or exhales to a particular volume usually FRC and then a shutter drops across their breathing tube. The subject makes respiratory efforts against the closed shutter. Measurements are based on Boyle's law which states that at constant temperature, the volume of a given mass of gas varies inversely with pressure. Therefore the increase in chest volume slightly reduces the box volume that is the non person volume of the box and thus slightly increases the pressure in the box. Static lung volumes can be measured either by measuring the changes in pressure in a constant volume box or volume in a constant pressure box. After the FRC is measured , the measurement of lung subdivisions like inspiratory capacity, expiratory reserve volume and vital capacity can be done. From these volumes and capacities , the residual volume and total lung capacity can be calculated

Nitrogen washout

This technique uses a non breathing open circuit. It is based on the assumption that the nitrogen concentration in the lungs is 78% and in equilibrium with the atmosphere , that the patient inhales 100% oxygen which replaces all the nitrogen in the lungs

Helium dilution

This technique uses a closed , rebreathing circuit. It is based on the assumption that a known volume and concentration of helium in air begin in the closed spirometer , that the patient has no helium in their lungs and that an equilibration of helium can occur between the spirometer and the lungs.

Diffusing capacity

It is the volume of a substance transferred across the alveoli per minute per unit alveolar partial pressure. CO is rapidly taken up by haemoglobin, its transfer is therefore limited mainly by diffusion. A single breath of 0.3% CO and 10% Helium is held for 20s. Expired Partial pressure of CO is measured. Normal value is 17-25ml/min/mm Hg. It is decreased in conditions such as pulmonary fibrosis and pneumonectomy.

Respiratory muscle function

A number of diseases such as motor neuron disease can result in respiratory muscle weakness, which can ultimately lead to respiratory failure

Inspiratory mouth pressure

A measure of inspiratory muscle function in which subjects generate as much inspiratory pressure as possible against a blocked mouth piece .Values of 80 cm of water or more exclude any significant inspiratory muscle weakness

Expiratory mouth pressure

A measure of expiratory muscle function in which subjects generate as much expiratory pressure as possible against a blocked mouth piece. Values of 80 cm of water or more exclude any significant expiratory muscle weakness

Overnight oximetry

It can be used in the initial assessment of obstructive sleep apnea. Typically 10 oxygen desaturations/hour of more than 4% would be considered indicative of OSA

Arterial Blood Gas Analysis

It provides important information on gas exchange and oxygen delivery to the tissues

Type I Respiratory failure - PaO2 less than 8kpa, normal PaCO2
Pneumonia , Pulmonary Embolism

Type II Respiratory failure - PaO2 less than 8kpa, PaCO2greater than 6.5kpa
COPD,respiratory muscle weakness

Cardio Pulmonary Exercise Testing

It involves patients exercising on a treadmill or cycle ergometer with measurement of variables such as ventilation, heart rate, oxygen uptake and cardiac output. It is useful in patients who complain of excessive breathlessness and in whom investigations echo and PFT are normal An oxygen uptake[VO2] peak standardized by body mass below 80 % predicted is considered abnormal

PFT in patients undergoing lung resection

Resection of primary lung cancers in the form of lobectomy or pneumonectomy remains the treatment of choice in patients with early stage disease. Many patients with lung cancer will also have COPD and it is important to try and determine the effect of lung resection on these patients both in terms of postoperative complications and long term disease

The British Thoracic Society guidelines advise pneumonectmy can be considered in patients with FEV1 greater than 2 litres and lobectomy if FEV1 is greater than 1.5 litres in the absence of any interstitial disease or unexpected disability due to shortness of breath.

As absolute values may be lower in older patients and women, patients are generally considered for resection if FEV1 is greater than 80% predicted and DLCO is greater than 80% predicted. In patients with borderline lung function the postoperative predicted FEV1 and DLCO can be calculated either with the knowledge of the number of lung segments to be resected or through quantitative lung perfusion scanning.

Patients with postoperative predicted FEV1 or DLCO less than 40% are deemed at high risk of perioperative death and complications. PFTs less than 30% predicted may be considered for lung transplantation if there is no other contraindication

Assessment of operative risk

The concerns are

1.Fit for GA
2.Appropriate for planned surgical procedure
3.Requires further treatment for any underlying respiratory problem

These decisions are made with inputs obtained from PFT. In a patient with chronic respiratory disease , it is important to identify how much of their breathlessness is due to their lung disease. Surgery may not be justified if their respiratory disease carries a poor prognosis by itself.

It is important to identify patients with respiratory problems who are at increased risk of complications such as respiratory infections, Acute Lung Injury which may result in difficulty in weaning postoperatively.

While no single test can effectively predict intraoperative and post operative mortality from pulmonary complications, the FEV1obtained from good quality spirometry is a useful tool. When the FEV1 is greater than 2 litres or 50 % of predicted, major complications are rare

Operative risk is heavily dependant on the surgical site, with chest surgery having the highest risk of postoperative complications followed by upper and lower abdominal surgeries. Patient related factors associated with increased operative risk for pulmonary complications include preexisting pulmonary disease, cardiovascular disease, pulmonary hypertension, dyspnoea on exertion, heavy smoking, respiratory infection with productive cough, advanced age,malnutrition , general debilitation , obesity and prolonged surgery