

QUARTERLY MEDICAL REVIEW

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CONTENTS

REVIEW

CURRENT CONCEPTS OF DIAGNOSIS AND MANAGEMENT OF BRONCHIAL ASTHMA

Definition	03
Physiological & Functional Alterations In Asthma	04
Mediators Implicated In Asthma And Their Function	05
Neurogenic Inflammation	05
Role Of Nitric Oxide (No) In Asthma	06
Clinical Presentation And Diagnosis	06
Classification Of Asthma	07
History	09
Common Allergens	09
Physical Examination	10
Pulmonary Function Test	10
Indicators Of Site Of Airway Obstruction	12
Laboratory Investigations	13
Bronchial Challenge Testing	13
Asthma Management	14
Goals Of Therapy	14
Stepped care in asthma therapy	16
Inhaled Steroids	18
Acute Severe Asthma	18
Risk Factors For Fatal Asthma	20
Long Term Management	21
Points To Be Remembered	21
References	21

THORACOSCOPY : OLD ART WITH A NEW LOOK

Introduction	23
Therapeutic Indications	24
References	27

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CURRENT CONCEPTS OF DIAGNOSIS AND MANAGEMENT OF BRONCHIAL ASTHMA

Dr. Anil Saxena*

Every breath that we take is synonymous with life. Asthma has been growing in prevalence and has imposed an increasingly large burden on health services.

Mortality related to asthma in old age has fallen steadily during the twentieth century. Mortality rate for asthma among young people is being noticed to have an increasing index due to prevailing epidemics and rising environmental pollution in day to day life¹. The statistics related to asthma shows that asthma affects about 120 million Indians².

This is the most common chronic illness of childhood affecting approximately 10% of children³. In mega cities of India, increasing urbanization and environmental pollution become prime factors in rising asthma prevalence.

The word asthma is derived from the Greek word meaning a short drawn breath, panting or labored breathing⁴. Asthma has been identified in ancient Egyptian and Hebrew writings. An extract of henbane (*Hyoscyamus*) was heated on a brick and its fumes were inhaled for treatment.

DEFINITION

In 1983, Scadding defined asthma as a disease characterized by wide variation over short period of time in resistance to flow in pulmonary airways⁵.

Today, asthma in the words of the National Heart, Lung and Blood Institute, 1995, is defined as “a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role, in particular mast cells, eosinophils, T-lymphocytes, macrophages, neutrophils and epithelial cells”.

This inflammation causes recurrent episodes of wheezing, breathlessness, chest tightness and cough particularly at night and/or in the morning.

The inflammation also causes an associated increase in existing bronchial hyperresponsiveness to variety of stimuli.

Pathological changes

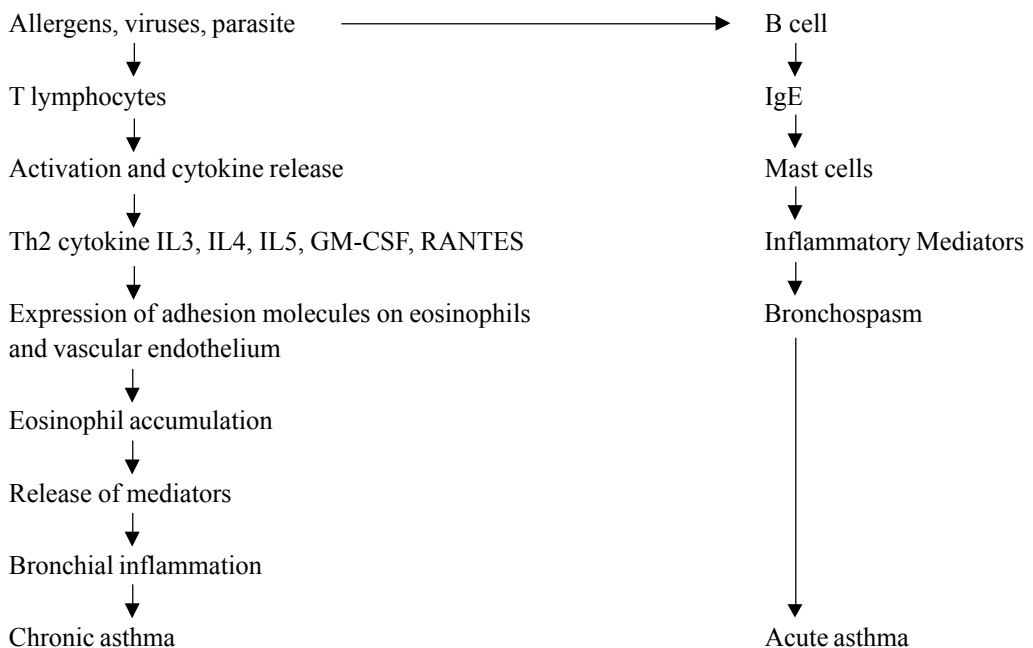
Pathological changes in asthma that result from inflammation are epithelial damage, shrinking of bronchial muscle, increase in bronchial capillary bed, fluid exudation with edema, goblet cell hyperplasia, airway smooth muscle (ASM) hyperplasia and hypertrophy, and intraluminal mucus and cellular debris causing complete/partial obstruction.

*Asst. Professor, Chest & TB, Medical College, Kota.
KR - 363, Chambal Garden Road, Dadabari, Kota-324009
Ph. : 0744-501670

PHYSIOLOGICAL & FUNCTIONAL ALTERATIONS IN ASTHMA⁶

- Reversible airway obstruction (Bronchospasm)
- Ventilation perfusion (V/Q) abnormalities and gas exchange
- Bronchial Hyper Reactivity (BHR)
- Irreversible airway obstruction
- Dynamic Hyperinflation.

Summary of Pathophysiology of asthma⁷



Antigen induced allergic response is Biphasic:

Immediate Response – Early Asthmatic Response (EAR) which is mediated by Histamine, Leukotrienes & PGD₂.

Late Response – Occur 2-8 hours later is called Late Asthmatic Response (LAR). Inflammation & BHR is due to ongoing LAR; EAR is responsible for reversible airway obstruction (Bronchospasm).

BHR (Bronchial Hyperreactivity)

Defined as ability of airways to narrow too much and too easily in response to a variety of specific

and non-specific stimuli and is an important feature of asthma⁶. This is best studied by bronchial provocation test using the agent histamine or methacholine.

PD₂₀ / PC₂₀ – Provocation Dose or Provocation Concentration at which 20% fall in FEV₁ occurs, is used to differentiate normal subjects from asthmatics.

BHR is a result of multiple and complex mechanisms not necessarily or uniquely related to inflammation.

MEDIATORS IMPLICATED IN ASTHMA AND THEIR FUNCTION

Several mediators play a crucial role in the pathology of asthma⁷. There are cytokines and chemokines, the neurogenic mediators and the bronchospastic and inflammatory mediators released mainly by mast cells.

Cytokines cause a characteristic inflammation of airways dominated by eosinophils and mononuclear cells.

Chemokines - Separate group of chemo attractant cytokines. It includes RANTES (Regulated upon Activation Normal T-cell Expressed and Secreted).

Monocyte chemotactic protein³, Eotaxin & IL8 are important in leukocyte migration through airways wall.

NEUROGENIC INFLAMMATION

Cellular inflammatory mediators influence the release of neurotransmitters or activate afferent nerves causing bronchoconstrictive reflexes. Nerves can also release neurotransmitters which have inflammatory effect. Cholinergic nerves are

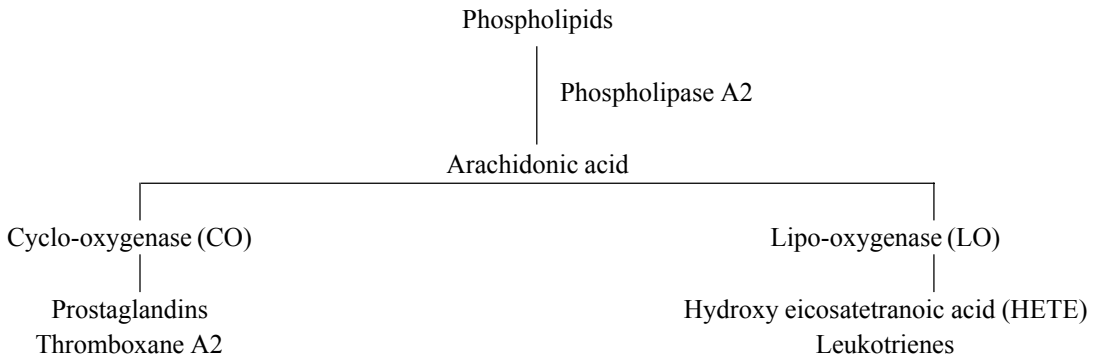
important in bronchoconstricting pathways through muscarinic receptors (M3).

There is however, no adrenergic supply to human airways but circulating adrenaline plays a role in the regulation of the bronchomotor tone.

Inflammatory mediators implicated in asthma and their effects on airway function⁸

Inflammatory mediators	Bronhoconstriction	BHR
Histamine	+	-
Bradykinin	+	-
Serotonin	+/-	-
Platelet activating factor (PAF)	++	++
LTB ₄	-	+/-
LTC ₄ , D ₄ , E ₄	++	+/-
PGD ₂ and PGF ₂	++	+
Thromboxane	++	+
Neurogenic		
Neurokinin A (NKA)	++	-
Substance P (SP)	+	-
Nitric oxide (NO)		
Cytokines and chemokines		
Interleukin (IL-4,5)		
GM-CSF		
IFN γ		

Eicosanoids-products of arachidonic acid (AA) metabolism



ROLE OF NITRIC OXIDE (NO) IN ASTHMA

Nitric oxide plays an important role in both physiological regulation of the airways and the pathophysiology of asthma.

Inflammatory cytokines and oxidants increase the expression of an inducible form of NO Synthetase (iNOS) in the airway epithelium of asthmatics. This results in an increased production of NO, as evident by increase level of the gas in exhaled air. NO has both beneficial and detrimental effect on the human airways.

Three forms of NO Synthetase act upon amino acid L-arginine to produce NO endogenously.

Constitutive forms	(cNOS)	Mucous secretion & Inflammation
Endothelial cells	(ecNOS)	Vasodilatation
Neuronal	(nNOS)	Bronchodilation

CLINICAL PRESENTATION AND DIAGNOSIS

In whichever way asthma is defined, the common features are :

- Periodicity
- Chronicity
- Reversibility

To patients, asthma means labored breathing,

accompanied by wheezing, a sense of constriction in chest and often attacks of coughing or gasping caused by conditions that interfere with normal inflow and outflow of air in the lungs.

To physicians asthma is clinical syndrome characterized by increasing responsiveness of the tracheobronchial tree to variety of stimuli, common symptoms are : cough, dyspnea and wheeze.

CLASSIFICATION OF ASTHMA⁹

PERSISTENT ASTHMA

Presence of an abnormal dose response curve to methacholine / histamine plus wheeze in the previous 12 months is classified as (current asthma) persistent asthma.

OBSTRUCTED ASTHMA

This is a form of persistent asthma with evidence of airflow limitation that persists after maximal treatment with bronchodilator and oral corticosteroids.

EPISODIC / SEASONAL ASTHMA

In this form of asthma, periodic episodes of symptoms of airway narrowing occur at intervals and are of sufficient severity to require treatment, but there is no detectable abnormality of air function between the episodes. Pathologic changes have not

been described.

ASTHMA IN REMISSION

An individual with a past history of persistent asthma who has had neither symptoms nor taken therapy for the last 12 months has some degree of persisting airway hyperreactivity (AHR).

POTENTIAL ASTHMA

An individual who has AHR, usually in the moderate range, but has no symptoms of asthma, may develop asthma at a later time.

TRIVIAL WHEEZE

An individual, without AHR, who has episodes of wheezing that are mild or short lived do not require treatment.

SUGGESTED CLASSIFICATION OF ASTHMA

Type	Symptoms	Bronchodilator required for symptoms	Baseline lung function (FEV ₁) (After broncho dilator)	Airway Responsiveness (By challenge or PEF variability)
Persistent asthma	Frequent	Regularly	> 80% Predicted	Increased-mild-severe
Obstructed asthma	Frequent	Regularly	<80% Predicted	Increased-mild-severe
Asthma in remission	Past but none > 12 months	None > 12 months	Normal, unchanged	Increased-mild
Potential asthma	None, ever	Never	Normal, unchanged	Increased-mild-moderate
Trivial wheeze	Intermittent, mild	No	Normal, unchanged	Normal

Classification of Asthma according to Severity⁹

Clinical features before treatment

	Symptoms	Night time Symptoms	Lung Function
Step 4 Severe persistent	Continuous symptoms Limited physical activity Frequent exacerbations	Frequent	FEV ₁ /PEF < 60% predicted PEF variability > 30%
Step 3 Moderate persistent	Daily symptoms Daily use of inhaled short acting beta2 agonist Exacerbations affect activity Exacerbations > 2 times a week; may last days	> once a week	FEV ₁ /PEF > 60- < 80% predicted PEF variability 20-30%
Step 2 Mild persistent	Symptoms > 2 times a week but < 1 time a day Exacerbations may affect activity	> 2 times a month	FEV ₁ /PEF > 80% predicted PEF variability < 20-30%
Step 1 Mild intermittent	Symptoms < 2 times a week Asymptomatic and normal PEF between exacerbations Exacerbations brief (from a few hours to a few days); Intensity may vary	< 2 times a month	FEV ₁ /PEF > 80% predicted PEF variability < 50%

Keys to asthma diagnosis¹⁰

- History :
 - Cough (especially nocturnal)
 - Recurrent wheeze (but absence of wheezing does not rule out the diagnosis)
 - Recurrent dyspnea
 - Recurrent chest tightness
- Occurrence or worsening of symptoms in association with specific factors :
 - Airborne chemicals or dusts
 - Animals with fur or feathers
 - Changes in weather
 - Exercise
 - House-dust mites (in mattresses, upholstered furniture, carpets)
 - Menses
 - Mould
 - Night-time (awakening the patient)
 - Pollen

- Smoke (tobacco or wood)
- Strong emotional expression (laughing or crying hard)
- Viral infection

- Reversible airflow limitation with diurnal variability
Variation in PEF of at least 20% between first morning measurement (before taking an inhaled, short-acting beta-adrenergic agonist) and early afternoon measurement (after taking an inhaled, short-acting beta-adrenergic agonist)

Diagnosis is made on the basis of history of typical symptoms and confirmatory objective evidence of variable airflow obstruction.

The frequent finding of an irreversible component of airways in older asthmatics also adds to the challenge of distinguishing between asthma and COPD.

Difference between asthma and COPD

	COPD	Asthma
Age group involved	>40 year	Any age
History of atopy	May or may not be present	Usually present
Symptoms	Slowly progressive	Episodic
Bronchodilator response	Usually < 15%	Usually > 15%
Steroid response	Variable (<15%)	Usually dramatic (>15%)
Antibiotics	Usually required in acute exacerbations	Rarely required
Inflammation	Neutrophilic	Eosinophilic
Chronic respiratory failure and cor pulmonale	Common in later stages	Very rare

Following clinical and laboratory manifestation are important in consideration of diagnosis of asthma :

HISTORY

During attack the main complaints are wheeze and sensation of tightness. There is sensation of difficulty in getting the air in.

Sometimes cough may be the only presenting symptom, due to exposure of triggering factor. Common triggering factors (Allergens) are :

COMMON ALLERGENS**House Dust**

Dust contains accumulation of household debris, particles of paint, skin scales, hairs, earth and so on. But as far as allergy is concerned, the most important component of dust is the house dust mite. Dust mites are tiny little creatures, which live in the bedding and furniture feeding on molds, and on human or animal skin scales or feathers. They grow fast in the damp, warm conditions of mattresses, and are especially abundant when the whole house is damp or situated near water.

Pollens

Grass pollen grains are an important cause of allergic diseases in all parts of India. The problem will be more on dry sunny and windy days and less on still, damp days. It is very difficult to get away from pollen grains altogether.

Animals

Most animals that have hair or feathers can cause

asthma. Because of close contact, several domestic pets can bother asthmatic patients. Children tend to develop animal allergy more often than adults and a child who has eczema is more likely to become allergic to animals. Male animals cause allergic asthma more than females.

Food Allergy

Eggs, milk, nuts, soya, seafood, fish, corn and wheat are the most common allergy causing foods but almost any food can cause allergy.

Nocturnal Symptoms

Early morning symptom/ nocturnal symptom (4-6 AM) are very common in asthmatic adults. We must distinguish nocturnal symptoms are due to asthma, gastro esophageal reflux or CVS events (angina/LVF).

Postulated mechanisms for nocturnal asthma include circadian variation in the level of catecholamines, cortisol, and chemical mediators capable of causing airway obstruction.

PHYSICAL EXAMINATION

Physical signs depend upon degree and duration of airway obstruction. They are tachypnea, tachycardia, pulsus paradoxus, and hyperinflation of chest, use of accessory muscles of respiration, diaphoresis, hyperresonance of percussion note, prolonged expiration. inspiratory and expiratory rhonchi and wheezes.

Full use of accessory muscles of respiration, diaphoresis, difficulty in maintaining speech and

cyanosis may reflect markedly severe asthma and impending ventilatory arrest.

Absence of wheezing on auscultation may be misleading in both mild and severe attacks because there may be insufficient collapse of bronchi or complete collapse of bronchi. All that wheezes need not necessarily be asthma! (e.g. vocal cord dysfunction) Complete examination of CVS must be done to rule out congestive heart failure.

PULMONARY FUNCTION TEST (PFT) – SPIROMETRY IS LIKE ECG OF LUNG

They are important for the following reasons :

- Confirming the diagnosis of asthma.
- Establishing the severity of disease.
- Monitoring the response to therapy.

The diagnosis of asthma is usually confirmed by objective demonstration of airways obstruction by spirometry.

Post bronchodilator increase of FEV₁ of 20% is often considered an evidence of reversible airway obstruction.

Some asthmatics, especially elderly patients, demonstrate persistent obstruction even when optimally treated and in remission. An empiric trial of oral glucocorticoids with spirometric monitoring before and after treatment is often necessary to identify patients with reversible airway obstruction. As a rule, 0.4 mg/kg prednisolone is administered daily for 2 weeks. Although the dose and duration of treatment are largely empirical, limited studies suggest that the response to systemic glucocorticoids is achieved in 8 days¹². Also, documentation of deterioration in lung function during an exacerbation followed by improvement after treatment is also evidence for a diagnosis of asthma.

The various lung functions are :

- Total Lung Capacity (TLC) is the volume of air in the lungs following a maximal inspiration. (Normal Range = 5 to 6 L)
- Forced Vital Capacity (FVC) is the maximal amount of air that can be exhaled following a maximal inspiratory effort. (Normal : Males=4.8 L Females 3.1 L).
- Tidal Volume (TV) is the volume of air that enters and leaves the lungs during normal breathing. (Normal=500 ml)
- Inspiratory Reserve Volume (IRV) is the maximal amount of air that can be inhaled from the end of a normal inspiration. (Normal range = 2 to 3.3 L)
- Residual Volume (RV) is the volume of air remaining in the lungs following a maximal expiratory effort. (Normal=2.1 L)
- Expiratory Reserve Volume (ERV) is the maximal amount of air that can be exhaled from the end of a normal expiration (Normal=1 L).
- Functional Residual Capacity (FRC) is the volume of air within the lungs at the end of a normal expiration. FRC is composed of two

primary lung volumes, expiratory reserve volume (ERV) and residual volume (RV). (Normal range 2.5 to 3 L)

- Inspiratory Vital Capacity (IVC) is the maximal volume of air inhaled after full expiration.
- Inspiratory Capacity (IC) is the volume of air taken during maximal inspiratory effort from the end of normal expiration. (Normal = 3500 ml.).
- Maximal Voluntary Ventilation (MVV) is the amount of ventilation a subject can breathe with maximal voluntary effort. Actual measurement is taken for 12 seconds and the results are extrapolated for a minute.
- Forced Expiratory Volume (FEV) is the volume of air exhaled in a given time during a forced vital capacity effort.

Similar to ECG, spirometry is also interpreted in two parts, namely spirometric tracings and spirometric data. Expiratory spirogram has two curves: flow-volume and volume-time curves along with computed parameters of volume and flow.

For the purpose of diagnosis the most commonly used indices are FVC, FEV_1 and FEV_1/FVC ratio. Other parameters are used as additional supporting evidence. Spirometry parameters depend on height, age, sex and race¹¹. FEV_1 in obstructive and FVC in restrictive disease are the best parameters for monitoring the progression of these diseases.

A. Forced Expiratory Volumes

- Forced Vital Capacity (FVC) : It is the volume of the air a person exhales with forceful expiration after maximal inspiration. Normally, it is reached within 3-4 seconds. Airway obstruction prolongs this time.
- Timed Volumes : During FVC manoeuvre, the volumes obtained in 0.5, 1 and 3 seconds are displayed as $FEV_{0.5}$, FEV_1 , and FEV_3 respectively.

These are reduced in both obstructive and restrictive lung diseases. The reduction is proportional to FVC in restrictive diseases, but is more marked in obstructive lung diseases. Forced expiratory volume in one second, (FEV_1) is the most commonly used parameter.

- FEV_1/FVC Ratio : Since timed volumes are dependent on vital capacity and body size, these show variations. The timed volume as the ratio of vital capacity reduces this variability. This ratio is a useful index for assessing the magnitude of airway obstruction.

B. Forced Expiratory Flows (FEF)

Expiratory flows, averaged over pre-selected segments of the spirogram, are used in assessment of airway functions. The information gathered from the flows is similar to timed volumes.

- Forced Expiratory Flow 200-1200 (FEF 2-12). It is the average flow during the first 200 to 1200 ml forced vital capacity.
- Forced expiratory flow 25-75% (FEF 25-75). It is the average flow during 25 to 75 percent of forced vital capacity.
- Forced expiratory flow 75-85% (FEF 75-85). It is the average flow during 75-85 percent of forced vital capacity.
- Forced expiratory flow 25% (FEF 25%). It is the average flow at exhalation of the first 25 percent of forced vital capacity.
- Forced expiratory flow 50% (FEF 50%). It is the average flow at exhalation of the 50 percent of forced vital capacity.
- Forced expiratory flow 75% (FEF 75%). It is the flow at expiration of 75 percent forced vital capacity.

INDICATORS OF SITE OF AIRWAY OBSTRUCTION

- Large airway
FEF 200-1200 and FEF 25% give information about large airways.
- Generalized
FEF 25-75 and FEF 50% are sensitive indices of airway obstruction present in most clinical conditions such as asthma and COPD. FEF 25-75 is also called Maximal Mid Expiratory Flow Rate (MMEFR).
- Small airways
FEF 75-85 and FEF 75% are indicators of small airway dysfunction. FEF 75-85 is also called maximal end expiratory flow rate.

TWO TYPES OF AIRWAY DEFECTS - RESTRICTIVE AND OBSTRUCTIVE

1. **Restrictive defects** - A group of diseases give a restrictive pattern in spirometry. This pattern is characterized by lower value of FVC with normal ratio of FEV_1/FVC . FVC is reduced in all restrictive defects because of reduction of intra-thoracic gas volume. FVC less than 40 percent of the predicted value is categorized as severe, 40 to 60 percent as moderate, and 60 to 80 percent as mild restriction. for follow-up asthma and COPD patients and in evaluation of bronchodilator response.
2. **Airways Obstruction** - Spirometric patterns in airway obstruction typically show reduced FEV_1/FVC ratio. It is a sensitive index of airflow obstruction. With age, normal values decline. Young persons have 85 percent, but it declines with age and becomes 65 percent at the age of 80 years. Once diagnosis of airflow obstruction is made, absolute values of FEV_1 are more useful Similar to restriction, airway obstruction is also described as mild, moderate and severe on the basis of FEV_1 . FEV_1 less than 80 percent of the predicted value is mild; less than 60 percent is moderate; and less than 40 percent is severe. If obstruction is associated with restriction, the FEV_1 cannot be taken as a criterion because it is also reduced in restriction. In such a situation, FEV_1/FVC percentage ratio should be employed. FEV_1/FVC percentage between 80 and 60 is mild; between 60 and 40 is moderate; and less than 40 is severe airflow obstruction. Timed flows are also abnormal in airway obstruction, but add little to FEV_1 .

PEAK EXPIRATORY FLOW RATE (PEFR)

This is lowest in the early morning and highest in late afternoon. Variability of PEFR is defined as ratio of difference between evening and morning values

to the mean of evening and morning value i.e. amplitude divided by the mean. This is the simplest way of measuring the degree of obstruction.

LABORATORY INVESTIGATIONS

LEUKOCYTE

WBC and RBC counts are normal in uncomplicated asthma. Treatment with steroid produces leukocytosis with eosinopenia and lymphopenia.

EOSINOPHILS

This is an important diagnostic feature of asthma. Sputum eosinophils increase. Peripheral blood eosinophilia in the range of 2500 cell/ml and levels of eosinophils and eosinophil protein in Broncho Alveolar Lavage (BAL) are increased in asthmatic patients.

SPUTUM EXAMINATION

During asthmatic relapse, sputum production is scanty. With recovery, moderate amounts of clear or yellow mucoid material may be produced. With prolonged relapse, there maybe daily clearing of bronchorrheic secretions of 100 ml or more; with recovery, expectoration of “kite strings” or miller seed bronchial casts are seen.

Microscopic examination of sputum from patients of chronic asthma reveals bronchial epithelial cells in cluster (Creola bodies), eosinophils, Charcot Leyden crystals and Curschmann’s spirals or mucinous materials of varying sizes from small airways. These features help to distinguish chronic asthma from chronic bronchitis¹³.

ARTERIAL BLOOD GASES

These are typically normal in patients with chronic stable asthma. In an acute episode, hypoxia is often

present. Arterial PCO₂ is typically reduced owing to hyperventilation. With severe obstruction, PCO₂ is increased due to fatigue of respiratory muscles. pH may be lower than predicted.

IMMUNOLOGICAL STUDIES

IgE antibody – elevation in total IgE is strongly associated with asthma and skin test reactivity is associated with allergic rhinitis¹⁵. Elevated IgE level (>100 IU) is seen in allergic patients but is not specific for asthma. Normal IgE level can not be used to exclude diagnosis of asthma.

IgG antibody – Late response show high level of IgG antibody. Levels more than 1800 mg% is considered significant. It is estimated by ELISA method.

ECG – Uncomplicated asthma shows sinus tachycardia. In status asthmaticus with respiratory failure ECG shows right axis deviation, P pulmonale, RBBB and Right ventricular strain.

Radiography – Usually normal in uncomplicated asthmatics.

Some of the patients show over-inflation, flattening of diaphragm, and increase AP diameter.

In chronic persistent or acute severe asthma, abnormalities such as atelectasis, thickening of bronchial wall, pneumonia, pneumothorax and pneumomediastinum can be seen. Paranasal sinus X rays are abnormal in adult asthmatics as compared to normal adult¹³.

BRONCHIAL CHALLENGE TESTING : (BRONCHOPROVOCATION TESTING)

There are three challenge tests :

- Inhalation (Methacholine / Histamine)
- For drug allergy (oral drug)
- Food allergy (oral food)

INHALATION

Abnormal airway responsiveness is detected in the laboratory by an exaggerated response to inhaled pharmacological agents such as histamine

and methacholine or a physical stimulus, such as exercise and hyperventilation. The most widely employed methods for airway challenge are based on administration of aerosolized solution of methacholine or histamine in increasing concentrations.

The intermittent and continuous aerosol generation techniques give remarkably similar results when airway responsiveness is expressed as the concentration of methacholine or histamine causing a 20% fall in FEV₁ (PD₂₀/PC₂₀) as determined from dose response curves. Some studies have shown that 100% of the patients with current asthma symptoms demonstrate a PC₂₀ at histamine concentration < 8 mg/ml while others using methacholine have reported a sensitivity of approximately 85% at the same PC₂₀ threshold.

It is estimated that approximately 10% of asymptomatic persons with a history of asthma retain elevated airway responsiveness. Likewise, approximately, 10-15% of atopic subjects without asthma demonstrate abnormal airway responsiveness. The prevalence of abnormal responsiveness in non-atopic, non-asthmatic subjects who have no history of prior respiratory problems ranges from 5-10%.

FOOD ALLERGY

Sensitization occurs as a result of pinocytosis of antigenic protein molecules by intestinal mucosal cells on an induction of IgE antibody response. Food may also provoke asthma via mechanisms that may not be related to IgE mediated allergy (e.g. preservative, sodium nitrate, benzoate dyes tartrazine)

ALLERGY TESTS

An allergic evaluation may be appropriate when the clinical history suggests that specific aero-allergens are important triggers in a particular patient and when asthma symptoms are accompanied by other symptoms typical of allergic disease, such as rhinitis and conjunctivitis.

The components of an allergic evaluation include detailed history of the patient's environment and possible triggers, followed by tests of allergic sensitivity. Sensitivity to a particular allergen (or the presence of IgE antibody) can be verified by skin tests or by in vitro serum antibody studies. Because of a high prevalence of positive skin tests in persons with no allergic symptoms, the clinical history is essential for making sound judgements concerning the importance of allergic triggers. Hence allergy evaluation is useful for developing avoidance treatment strategies or, in selected cases, for developing immunotherapy regimens.

ASTHMA MANAGEMENT¹⁶⁻¹⁸

1. Prevent attacks.
2. Reverse acute episodes.
3. Maintain normal bronchial physiodynamics.
4. Take care of psychological factors.

GOALS OF THERAPY

- Preventing chronic and troublesome symptoms.
 - Maintaining nearly normal pulmonary function.
 - Maintaining normal activity level (including exercise).
 - Preventing recurrent exacerbation and minimizing the need for emergency care and hospitalization.
- Anti asthma drugs are classified in two groups –

Relievers and Preventors

Relievers treat the spasm component. Preventors deal with swelling component of asthma.

Relievers – They relieve acute bronchospasm by relaxing the bronchial smooth muscles.

Reliever drugs:

- Give immediate relief from symptoms
- Effective for 4 to 6 hours
- Generally used in conjunction with Preventors.

Commonly used drugs are -

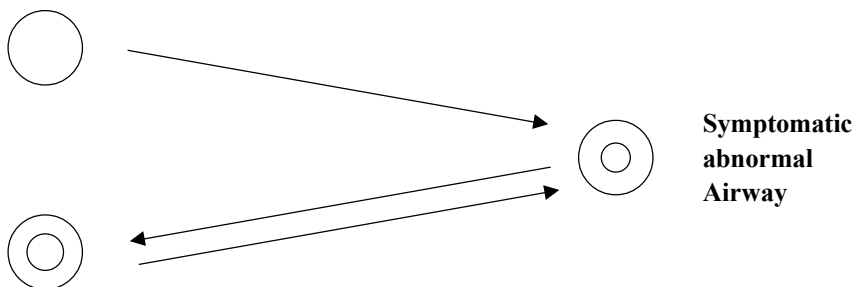
1. Short acting β_2 agonists – Salbutamol / Terbutaline
2. Anticholinergic - Ipratropium bromide
3. Short acting Theophylline
4. Adrenaline injection

Preventors

They help to prevent acute attacks of bronchospasm and reduce their frequency by controlling underlying inflammation. These drug do not give immediate relief from symptoms. Onset of action is delayed but duration of action is long. Most of the asthmatics, though asymptomatic, have abnormal airways due to underlying inflammation. These patients frequently develop symptoms without adequate preventive treatment.

Thus they shuttle between symptomatic and asymptomatic state.

Asymptomatic normal airway



Asymptomatic abnormal airway

Stepped care in asthma therapy : The medications¹⁷

Step	Daily medication for long-term control	Medication for quick relief
Step 1 Mild intermittent	No daily medication	Short-acting inhaled β_2 – agonist Use more than twice weekly may indicate need to initiate long-term therapy
Step 2 Mild persistent	One daily medication Anti-inflammatory agent (low-dose inhaled glucocorticoid, cromolyn or nedocromil.) or Sustained-release theophylline Note : Leukotriene modifiers may be considered	Short-acting inhaled β_2 - agonist Daily use or increasing use indicates need for additional long term therapy.
Step 3 Moderate	One or two daily medications Anti-inflammatory agent (medium-dose inhaled glucocorticoid) and/or Medium-dose inhaled glucocorticoid plus long-acting bronchodilator	Short-acting inhaled β_2 - agonist Daily use or increasing use indicates need for additional long-term therapy
Step 4 Severe Persistent	Two daily medications Anti-inflammatory agent	Short-acting inhaled β_2 -agonist Daily use or increasing use indicates need for additional long-term therapy.

Common Preventors are:

Corticosteroids Inhaled - Beclomethasone / Budesonide / Fluticasone
Oral / Parenteral

Mast cell stabilizer Sodium cromoglycate / Ketotifen

Long acting β_2 agonist Inhaled Salmeterol / Oral sustained release Salbutamol / Terbutaline

Long acting theophylline**MODE OF DELIVERY**

INHALATION - This is the route of choice. A number of inhaler devices are available in India²¹. They are inexpensive, portable, have instantaneous effect, and are ready for use.

Spacer Device

It constitutes the volume into which the patient actuates the metered dose inhater (MDI) and from which patient then inhales without necessarily having

to coordinate the two maneuvers. When the drug reaches the patient it will be moving more slowly and will result in better distribution. There is less oropharyngeal deposition. Spacers do not benefit the patient whose inhaler technique is adequate.

Single Dose Dry Powder Inhaler

Simple alternative to MDI.

Rotahalers – In these capsule is inserted into the end of device and is broken into 2 halves by twisting the mouth piece relative to barrel. Powder falls in the body of inhaler and patient simply has to inhale through mouth piece (% of delivery 6.2%). This does not require coordination so children and elder patient can use this.

ORAL PARENTERAL β_2 AGONIST¹⁸

Short acting β_2 agonist : Salbutamol, Terbutaline.

They are mainstay drugs for acute relief of asthma symptoms. They should generally be used on “as needed basis”.

Dosage

Oral

Salbutamol 0.15 mg/kg 6 hourly maximum single oral dose of 4 mg.

Terbutaline 0.075 mg/kg /dose 6 hourly

Metered Dose Inhaler

Salbutamol – 100 mcg/inhalation 1-2 inhalations as required 3-6 hourly

Terbutaline – 250 mcg/inhalation – 1-2 inhalations as required 3-6 hourly

For acute symptoms up to 4 inhalations if necessary repeat 4 times.

Rotahaler

Salbutamol 200 mcg cap. 1-2 caps. required 3-6 hourly

Nebuliser Solution

Salbutamol 5 mg / ml, children 0.02 ml / kg / dose maximum of 1 ml diluted with saline 3-6 hourly.

Salbutamol Respules

Children 4-12 years – 2.5 mg in 2.5 ml every 3-6 hour

Adult – 5 mg in 2.5 ml 3-6 hourly

THEOPHYLLINE

The availability of good sustained release preparations has made theophylline a useful drug for the treatment of nocturnal asthma. Sustained release theophylline preparations are now classified as “long-term preventive medication”.

Theophylline has anti-inflammatory effects as well as bronchodilator effects. There are recent suggestions that anti-inflammatory effects may provide an alternative rationale for the use of theophylline in asthma.

Common side-effects include anorexia, nausea, and headache and sleep disturbance. In young children, altered mood and behavior are so common as to limit theophylline’s acceptability in this age group. There are concerns that this drug may adversely affect concentration and cognitive skills in children. Long-term, high doses should be avoided if possible. Theophylline may aggravate gastroesophageal reflux.

This drug has narrow therapeutic index, which means that the side-effects appear early as the dose increases.

Therapeutic plasma level – 10-20 mg / L.

Dosage

Adult – 13 mg / kg / day maximum of 900 mg

Low doses are required in elderly, cardiac failure and liver diseases.

INHALED STEROIDS¹⁹

Beclomethasone, budesonide and fluticasone propionates are available in India. Fluticasone does have systemic side-effects. Budesonide is three times safer than fluticasone as regards to HPA axis²⁰. Fluticasone can suppress HPA axis even at low dose²¹. There is a doubt about the safety of fluticasone in children.

Budesonide appears to be the safest of inhaled corticosteroids.

Disodium cromoglycate inhibits antigen-induced inflammatory mediator release. It is protective in exercise-induced and antigen-induced bronchoconstriction. It is administered by inhaler route.

Ketotifen is described as a prophylactic asthma compound. It is an H₁ receptor antagonist and has a mast cell stabilizing effect.

IMMUNO THERAPY²²

It is another modality available for the treatment of asthma. Specific Immuno Therapy (SIT), discovered by Noon at St. Mary's Hospital, London is being advocated as one of the treatment modalities since past almost nine decades.

SIT in asthma is effective in reducing symptoms on specific exposure and in reducing bronchial

sensitivity to allergens.

SIT can safely be given in pregnancy. It is recommended only for inhaled allergens viz. pollen, fungi, insects, dust and dust mites. SIT has no place in the treatment of food allergies and allergies to animals. The duration of 5 years is generally accepted for the therapy.

ACUTE SEVERE ASTHMA²³⁻²⁸

Acute severe attack, previously called status asthmaticus, occurs spasmodically and unpredictably. In this progression of attacks of bronchospasm occur up to the point where the patient is breathless at rest and has signs of cardiac stress.

Patient sits up in bed / chair; wheezes are audible usually without stethoscope and chest is visibly overinflated. Sweating may be profuse. Tachycardia and

pulsus paradoxus (fall in systolic pressure during inspiration may be as much as 50-60 mmHg) are good indicators of severity. Low PEF and Arterial blood gas analysis indicates the severity of attack.

Two signs are of crucial importance - rising pulse rate and increasing anxiety or fatigue. Serum potassium should be checked daily in case of fall in response to treatment.

SEVERITY OF ASTHMA EXACERBATIONS

	Mild	Moderate	Severe	Respiratory Arrest Imminent
Symptoms:				
Breathless	While walking	While talking (infant – softer, shorter cry; difficulty feeding)	While at rest (infant – stops feeding)	
Talks in	Sentence	Phrases	Words	
Alertness	May be agitated	Usually agitated	Usually agitated	Drowsy or confused
Signs :				
Respiratory rate	Increased	Increased	Often > 30/min	
Use of accessory muscles; suprasternal retraction	Usually not	Commonly	Usually	Paradoxical thoracoabdominal movement
Wheeze	Moderate, often only end expiratory	Loud, throughout exhalation	Usually loud; throughout inhalation and exhalation	Absence of wheeze
Pulse/min.	< 100	100-120	>120	Bradycardia
Pulsus paradoxus	Absent < 10 mm Hg	May be present 10-25 mm Hg	Often present > 25 mm Hg (adult) 20-40 mm Hg (child)	Absence suggests respiratory muscle fatigue
Functional assessment :				
PEF % predicted or % personal best	80%	Approx. 50-80%	<50%, of personal best or response lasts < 2 hrs.	
PaO ₂ (on air)	Normal (test not usually necessary)	> 60 mm Hg (test not usually necessary)	<60 mm Hg possible cyanosis	
and/or				
PCO ₂	<42 mm Hg (test not usually necessary)	<42 mm Hg (test not usually necessary)	> 42 mm Hg possible respiratory failure	
SaO ₂ % (on air) at sea level	>95% (test not usually necessary)	91-95%	<91%	

Hypercapnia (hypoventilation) develops more readily in young children than in adults and adolescents.

*Notes:

- The presence of several parameters, but not necessarily all, indicates the general classification of the exacerbation.
- Many of these parameters have not been systematically studied. They serve only as general guides.

1. OXYGEN

Most of the patients admitted in hospital due to acute severe asthma have hypoxemia. This is due to V/Q imbalance. Low flow oxygen should be given. FIO₂ 35-50% are usually adequate. Nasal prongs are the best mode for administration of oxygen.

2. NEBULIZED β_2 AGONIST

In this the drug delivery is less dependant on a coordinated breathing pattern. Nebulized Salbutamol / Terbutaline in a dose of 5 mg diluted 2-3 ml of normal saline must be given promptly. Dose should be repeated every hour till the patient is settled.

3. INJECTABLE β_2 AGONIST

Subcutaneous injection of terbutaline is effective. It can be given 4-6 hourly.

4. STEROID

Because of inflammation this is the drug of choice. Dose is 200 mg of hydrocortisone every 6-8 hours. Once the patient's condition settles we should shift him to oral steroid.

5. AMINOPHYLLINE

Loading dose is 6 mg/kg diluted in 20 ml of 5% dextrose.

Maintenance dose 0.6-0.9 mg/kg / hour in 5% dextrose.

6. ADRENALINE

Subcutaneous injection has very quick effect. It has cardiac toxicity especially in elderly patient. So it should be used cautiously.

7. HYDRATION

Dehydration occurs during the attack because of low intake of fluid and excessive sweating. Adequate hydration with oral and IV fluids is necessary.

8. IPRATROPIUM BROMIDE

Nebulization in the dose of 500 mcg 6 hourly has some bronchodilator effect.

9. ANTIBIOTIC

Infection is the common trigger factor. Such infections are usually trivial. Thus routine administration of antibiotic is not recommended.

10. OTHER DRUGS

Use of magnesium (10 meq/20 min), Helium-Oxygen, Ketamine is effective.

Asthma management system can be divided in three zones

GREEN ZONE

Asthma under control: No nocturnal symptoms, No limitation of activity, PEFR 80-100% with <20% variability. If patient stays in green zone for at least 3 months, consider step down.

YELLOW ZONE

Signal caution: Asthma symptoms present, PEFR 60-80% variability 20-30%. Means acute exacerbation and indicates step up the treatment.

RED ALERT ZONE

Medical alert: PEFR <60%, high symptom score. Immediate medical attention and hospitalization.

RISK FACTORS FOR FATAL ASTHMA

- Co-morbidity (as from cardiovascular or chronic obstructive pulmonary disease).
- Current use of or recent withdrawal from systemic glucocorticoids.
- Difficulty perceiving airflow obstruction or its severity.
- History of sudden, severe exacerbations.
- Hospitalization or emergency care for asthma

within past month.

- Illicit drug use.
- Low socio-economic status and urban residence.
- Prior admission to intensive care unit for asthma.
- Sensitivity to *Alternaria* fungus.
- Serious psychiatric disease or psychosocial problems.
- Three or more emergency care visits for asthma in the past 1 year.
- Two or more hospitalizations for asthma in the past 1 year.
- Use of three or more canisters of inhaled short-acting adrenergic agonist per month.

LONG TERM MANAGEMENT

There are three precepts for maintaining control over asthma.

- 1) Prescribe daily anti-inflammatory therapy to provide most effective control. Early use of inhaled glucocorticoid can improve asthma control, normalize pulmonary function and prevent irreversible damage.
- 2) Follow the stepped care approach by initiating therapy at higher level and stepping down as stability is achieved.

- 3) Perform office based assessment at intervals ranging from 1-6 months.

Formeterol/salmeterol inhaler can be used individually as well as with the application steroid for a long term management in view of its prescribed administration effectively for a longer duration for about twelve hours or so.

Formeterol is considered superior to salmeterol since onset of its action is much earlier. As explained above formeterol contains effectively dual functions of doses administered.

LEUKOTRIENE MODIFIERS

Nowadays, they are available in India and may be considered alternative therapy to low dose steroid or cromolyn in mild persistent asthma. Although further clinical experience and study are needed to help establish their role in asthma therapy.

The cost of therapy is exorbitantly higher and can not be used exclusively unless it is associated with the administration of other prescribed doses of medicine.

POINTS TO BE REMEMBERED

1. Good history and clinical examination is necessary for diagnosis of asthma.
2. Investigation – PFT is most important, Blood to be tested for eosinophils, IgE-IgG level.
3. Asthma management program involves the participation for the patient along with the doctor for monitoring the therapy
4. Management of asthma comprises of long-term management and management of acute exacerbations.

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THORACOSCOPY : OLD ART WITH A NEW LOOK

Dr. Amir M. Khoja*

INTRODUCTION

In this era of keyhole surgery it was quite surprising that thoracoscopy lagged behind inspite of being an old technique. Thoracoscopy was developed by Swedish internist Jacobaeus in as early as 1910. This technique was used mainly for adhesiolysis for the treatment of tuberculosis. But as the chemotherapy for tuberculosis came into practice the role of thoracoscopy became less relevant. After the development of endoscopic surgery and the optics, the practice of thoracoscopy has become popular. Thoracic surgeons developed this technique for the surgery of lung, esophagus, mediastinum and the heart. The chest physicians started using this technique for the diagnosis of pleural diseases and mainly for effusions. It was popular in European countries but in last decade it has become popular in North American countries. In recent years it has been used for thoracic surgery in the form of pneumonectomy, sympathectomy, esophageal surgeries, lobectomy and pleurodesis.

History and evolution: Thoracoscopy has advanced to a great extent since Kelling first visualized the pleural cavity in a dog in 1902. Jacobaeus used distally lighted cystoscope for investigating tubercular effusions. In 1930 Jacobaeus performed operations to cut the adhesions to facilitate artificial pneumothorax in patients of tuberculosis. Since 1950 the procedure has undergone several technical developments. In addition the well developed optics of telescopes and the advanced documentation system have improved the utility. This has helped in a good recording of the procedure. Since then this procedure is being used by Pulmonologists And the Thoracic Surgeons in all the parts of the world.^{1,2}

In 1925 Jacobaeus published his accumulated work done on diagnostic pleural effusion. The increase in the application of diagnostic thoracoscopy in biopsy of the pleura and lung made it the base of essential diagnostic tool in the armament of the chest physicians. Looking at this it seems that this technique is going to last for a very long time.

Advantage of thoracoscopy over thoracostomy:

1. Less invasive.
2. Can be done under local or general anesthesia.
3. Less painful.
4. Less morbidity and mortality.
5. Faster recovery.
6. Equal sensitivity and specificity and less incapacitating.
7. Short hospital stay.

Indications for thoracoscopy:

Diagnostic:

1. Recurrent pleural effusions.
2. Recurrent pneumothorax.
3. Interstitial lung disease.
4. Evaluation of peripheral lung mass.
5. Evaluation of mesothelioma.
6. Evaluation of the chest wall mass.
7. Deciding about surgical decortication.

*Director and Head, Dept. of Chest Medicine and Thoracic Endoscopy,
Ruby Hall Clinic, PUNE. India.

Therapeutic Indications:

1. Pleurodesis for recurrent pleural effusion.
2. Drainage of loculated empyema.
3. Adhesiolysis for empyema.
4. Evaluation of hemothorax.
5. Wedge resection.
6. Bullectomy for recurrent pneumothorax.
7. Resection of peripheral nodule.
8. Removal of foreign body.
9. Lung biopsy.
10. Sympathectomy for vasculomotor syndromes of upper limbs.
11. Surgery for esophagus.

**CONTRAINDICATIONS FOR
THORACOSCOPY**

Absolute : 1. Gross debility,
2. pO₂ less than 50,
3. Bleeding tendency,
4. Platelet > 70000/cmm,
5. No pleural space.
Relative : Honey comb lung, Hydatid cyst, AV aneurysms.

Clinical application³:**Pleural effusions:**

The common cause of pleural effusion is TB, tuberculosis. In TB repeated pleural fluid aspiration shows exudates and repeated biopsies are negative. This becomes the ideal indication for thoracoscopy. The chances of getting a positive biopsy with thoracoscopy is 90-95% while that of closed pleural biopsy is around 30 to 40%. Hence thoracoscopy becomes ideal tool for biopsy of pleura. The

loculation of pleura can be broken by forceps or scissors. Biopsies can be taken from pleural nodules by using forceps with cautery attached to the forceps and can be done under direct vision. Even a small nodule can be picked up under direct vision and hence the accuracy is nearly 95 to 97 percent. Therefore most experts agree that when initial evaluation of pleural effusion is not diagnostic and neoplastic lesion is suspected, thoracoscopic exploration and pleural biopsy should be considered. The patients in whom malignancy is suspected, but fluid cytology is negative, thoracoscopic biopsy should be done instead of closed pleural biopsy. The positive results of thoracoscopic biopsy are as high as 90-100%.

Malignant mesothelioma:

The diagnosis of malignant mesothelioma may be suspected based on history of asbestos exposure, pleural fluid cytology and radiological picture. However, the final diagnosis is very difficult even on thoracoscopy as the lesion is difficult to visualize under direct vision.

Chylothorax:

It is caused by either trauma or by primary lymphoma. The thoracoscopy visualization is possible as it can show the torn thoracic duct. It can be endoscopically ligated. Talc pleurodesis can be very useful in such patient.

Recurrent Pneumothorax:

In cases of recurrent pneumothorax it is very essential to find the cause of the pneumothorax which is usually emphysematous bulla or bleb. Bullae are seen at the periphery. Such bullae can be stapled or cauterized by using cautery or harmonic scalpel.

Evaluation of Hemothorax:

Thoracoscopy is a useful tool in the patients of chest trauma to assess the extent of injury to diaphragm and lung laceration.

Loculated Empyema:

Cases of loculated empyema are commonly seen in the country like India where tuberculosis is very common and bad oral hygiene is also common due to tobacco chewing. It is advantageous to perform thoracoscopy to cut the adhesions under direct vision. It is possible to undertake decortication in early stages of empyema when the pleura is not very thick and the lung is still not firmly trapped.

Pleurodesis:

Talc pleurodesis is very effective treatment in cases of the recurrent pneumothorax and pleural effusions. Talc insufflation or slurry is the common mode of treatment which is done with talc automiser. Pleural abrasion can be carried out with the help of scissors or rubbing the pleura with a gauze piece. Parietal pleurectomy is also one of the modes of pleurodesis.



Talc automiser

Lung Biopsy:

Lung biopsy can be done with a thoracoscopic instrument where the biopsy can be under direct vision with the help of biopsy forceps or staplers. Wedge biopsy of the lung can be taken. The yield of biopsy is very high. Patients with diffuse lung disease and millary lesions can be very easily biopsied.

Pericardiectomy:

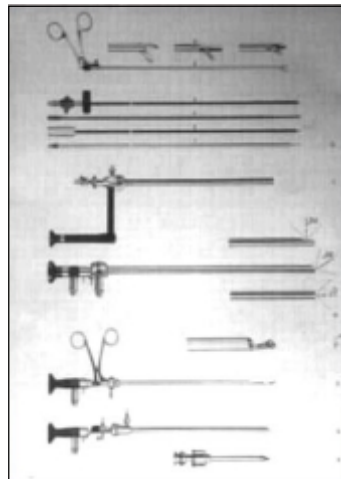
This is done in patients with recurrent pericardial

effusion where malignant effusion is common. The pericardial window can be done under direct vision. It is usually done on the left side as the right ventricle is a thin structure.

Thoracoscopy can be used for ligation of a Patent Ductus Arteriosus as well as to harvest internal mammary artery in patients undergoing Coronary Artery Bypass Graft surgery.

Sympathectomy:

Cervical sympathectomy is carried out for of vasculomotor symptoms in upper limbs. The lower sympathetic ganglia are located under direct vision in the chain and are cut. It is a very rewarding procedure and the results are dramatic.

Instruments:

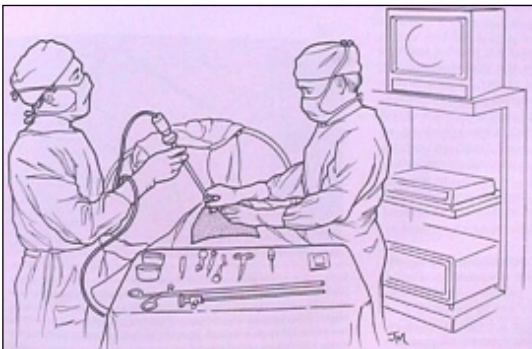
The various instruments which are used in thoracoscopy are same as those used for laparoscopy. The differences are in the length and the curvature. The cautery is used mainly for coagulation and cutting. Different kinds of telescopes and forceps are used. The clips and staplers are used while taking biopsies. Different kinds of ports are used to pass camera, and various other instruments.

Anesthesia: The thoracoscopy is done under local or general anesthesia. The diagnostic procedures are

usually done under local anesthesia and the therapeutic procedures are done under general anesthesia. Usually one lung ventilation is used while performing therapeutic procedures.

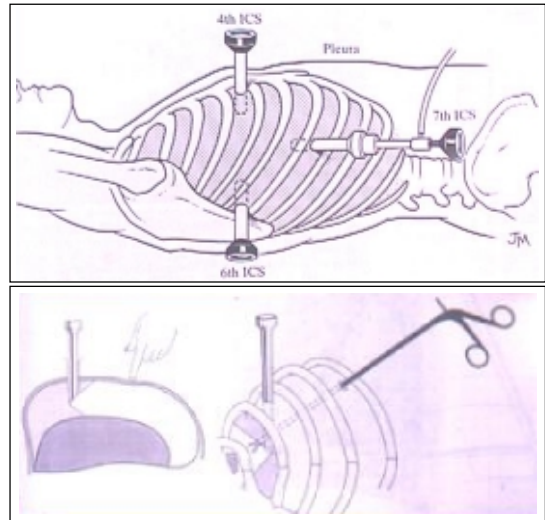
Position:

The procedure is carried out in supine or lateral decubitus position. The Kidney Bridge is usually used. The intercostal spaces are opened up well by the Jack Knife Position.



Procedure:

The patient is anesthetized and the position given with the side of abnormality up. The area is painted and draped. The camera, the cautery and the various instruments are arranged on the trolley. The port of entry is decided by the X-ray and the CT scan. The first port is usually in the mid/axillary line in the sixth intercostal space. A 10 mm trocar is passed through the incision made and through that telescope with camera is passed. Once the position is confirmed the second port is made under vision in the sixth intercostal space and section is done and



the forceps is passed. After visualizing the pleural cavity the pathological site is detected and a biopsy forceps is passed through the second port. The cautery is attached to the biopsy forceps. After catching the tissue, the cautery is applied so that the tissue remains in the cup of forceps and is not burnt. This tissue is taken out and preserved. After the biopsies are taken adequately the pleural cavity is thoroughly searched for any active bleeding. When large amount of effusion is present, the fluid is sucked out and the pleural cavity is visualized. Several biopsies are taken from different sites. They are taken against the ribs, so that the vascular bundle is spared. Lung biopsies are done in cases of diffuse lung disease on millary shadows in the lung. After the biopsies the talc pleurodesis is carried out. The intercostal drain is put in the pleural cavity under direct vision, and is connected to the underwater seal. The stay in the hospital is usually less than a week.

Complications:

The complications are as such not very common but one must be aware of the complications. The mortality is as low as 0.24% in experienced hands. The commonest complications are,

1. Bleeding.

2. Surgical emphysema.
3. Prolonged air leak.
4. Persistent pneumothorax.
5. Intercostal nerve and vessel injury.
6. Infection.
7. Complications related to anesthesia.
8. Malignant seeding of the chest wall.

Conclusions:

In this era of endoscopic surgery it is essential for the chest physician to have a thorough experience of thoracoscopy and one must use it judiciously and carefully to avoid complications. Needless to say that open surgery has its own role. The patients for thoracoscopy have to be selected in a proper manner and the procedure converted into open surgery whenever necessary. If the surgeons and the physicians work hand in hand than there is no problem whatsoever in the management of the chest diseases. Thoracoscopy is like a rose flower but of course the thorns are always there if the procedure is not performed in a proper manner.

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