"STUDY OF PULMONARY FUNCTION TESTS IN CARDIAC PATIENTS"

Dissertation submitted to

THE TAMIL NADU DR.M.G.R. MEDICAL UNIVERSITY

CHENNAI, TAMIL NADU

in partial fulfillment for the Degree of

DOCTOR OF MEDICINE - BRANCH I GENERAL MEDICINE

APRIL 2016

TIRUNELVELI MEDICAL COLLEGE HOSPITAL

TIRUNELVELI – 11, TAMIL NADU

CERTIFICATE

This is to certify that the Dissertation entitled **"STUDY OF PULMONARY FUNCTION TESTS IN CARDIAC PATIENTS"**submitted by **Dr.M.MATHAN** to The TamilnaduDr. M.G.R. Medical University, Chennai, in partial fulfillment for the award of M.D.Degree(GENERAL MEDICINE) is a bonafide work carried out by him under my guidance and supervision during the course of study 2013-2016. This dissertation partially or fully has not been submitted for any other degree or diploma of this university or other.

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CERTIFICATE OF REGISTRATION & APPROVAL OF THE TIREC REF NO: 534/GM/2014/41

PROTOCOL TITLE: STUDY OF PULMONARY FUNCTION TESTS IN CARDIAC PATIENTS.

NAME OF PRINCIPAL INVESTIGATOR: Dr. M.Mathan, MBBS.,
DESIGNATION OF PRINCIPAL INVESTIGATOR: Post Graduate in MD General Medicine
DEPARTMENT & INSTITUTION: Department of General Medicine, Tirunelveli Medical College

Dear Dr. M. Mathan, *The Tirunelveli Medical College Institutional Ethics Committee (TIREC) reviewed and discussed your application during the IEC meeting held on 14.05.14.*

THE FOLLOWING DOCUMENTS WERE REVIEWED AND APPROVED

1.	TIREC Application Form	☐
2.	Study Protocol	☐
3.	Department Research Committee Approval	☐
4.	Patient Information Document and Consent Form in English and Vernacular Language	☐
5.	Investigator's Brochure	☐
6.	Proposed Methods for Patient Accrual Proposed	☐
7.	Curriculum Vitae of the Principal Investigator	☐
8.	Insurance /Compensation Policy	☐
9.	Investigator's Agreement with Sponsor	☐
10.	Investigator's Undertaking	☐
11.	DCGI/DGFT approval	☐
12.	Clinical Trial Agreement (CTA)	☐
13.	Memorandum of Understanding (MOU)/Material Transfer Agreement (MTA)	☐
14.	Clinical Trials Registry-India (CTRI) Registration	☐

THE PROTOCOL IS APPROVED IN ITS PRESENTED FORM ON THE FOLLOWING CONDITIONS

1. The approval is valid for a period of 2 year/s or duration of project whichever is later
2. The date of commencement of study should be informed
3. A written request should be submitted 3weeks before for renewal / extension of the validity
4. An annual status report should be submitted.
5. The TIREC will monitor the study
6. At the time of PI's retirement/leaving the institute, the study responsibility should be transferred to a person cleared by HOD
7. The PI should report to TIREC within 7 days of the occurrence of the SAE. If the SAE is Death, the Bioethics Cell should receive the SAE reporting form within 24 hours of the occurrence.
8. In the events of any protocol amendments, TIREC must be informed and the amendments should be highlighted in clear terms as follows:
   a. The exact alteration/amendment should be specified and indicated where the amendment occurred in the original project. (Page no. Clause no. etc.)
   b. The PI must comment how proposed amendment will affect the ongoing trial. Alteration in the budgetary status, staff requirement should be clearly indicated and the revised budget form should be submitted.
   c. If the amendments require a change in the consent form, the copy of revised Consent Form should be submitted to Ethics Committee for approval. If the amendment demands a re-look at the toxicity or side effects to patients, the same should be documented.
   d. If there are any amendments in the trial design, these must be incorporated in the protocol, and other study documents. These revised documents should be submitted for approval of the IEC, only then can they be implemented.
   e. Approval for amendment changes must be obtained prior to implementation of changes.
   f. The amendment is unlikely to be approved by the IEC unless all the above information is provided.
   g. Any deviation/violation/waiver in the protocol must be informed

STANDS APPROVED UNDER SEAL

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Originality | GradeMark | PeerMark

STUDY OF PULMONARY FUNCTION TESTS IN CARDIAC PATIENTS

BY 201311300 MD GENERAL MEDICINE MATHAN

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PAGE 1 OF 84

Text-Only Report

ABBREVIATIONS

RHD- rheumatic heart disease

CCF-congestive cardiac failure

MI- myocardial infarction

CHF-congestive heart failure

SLE- systemic lupus erythematosis

LVH-left ventricular hypertrophy

LVF- left ventricular failure

IHD- ishemic heart disease

HTN-hypertension

PND-paroxysmal nocturnal dyspnea

BUN-blood urea nitrogen

BNP-brain natriuretic peptide

CHD- congenital heart disease

CAHD-coronary artery heart disease

PFT-pulmonary function tests

FVC - Forced Vital Capacity

FEV1 - Forced Expiratory Volume in One Second

FEV3 - Forced Expiratory Volume in Three Seconds

PEFR - Peak Expiratory Flow Rate

FEF - Forced Expiratory Flow

MVV - Maximal Voluntary Ventilation

VC- vital capacity

RC- residual capacity

TLC-Total lung capacity

COPD-chronic obstructive pulmonary disease

CONTENTS

INTRODUCTION

Coronary artery heart disease and rheumatic heart disease are among the most common causes of morbidity and mortality in India. These two diseases are the most common causes of cardiac failure. Patients with these diseases should have regular follow-up with doctors.

Heart failure is seen to be a highly common disease affecting about 1% of people in their 50s and increasing rapidly to 10% prevalence in their 80s.The annual incidence range is from 0.2% in 45 to 55 years of age to 4% in 85 to 95 years of age, with approximate doubling in each decade of life. Male predominance is seen because of high incidence of coronary artery heart disease occurring in males which in turn leads to 4 times increased risk of heart failure.

Impaired pulmonary function is common in cardiac patients. Respiratory muscle wasting has been well documented in Rheumatic Heart Disease patients. But Pulmonary Function Test is the least common test that

is undergone by the patients. This current study is aimed to assess the Pulmonary Function of cardiac patients with coronary artery heart disease and rheumatic heart disease who have recovered from cardiac failure.

AIM AND OBJECTIVES

- To study the Pulmonary Function Test patterns in patients with coronary artery heart disease and Rheumatic Heart Disease who have revived from Cardiac Failure.
- To diagnose any underlying undiagnosed respiratory problem coexisting with cardiac failure.

REVIEW OF LITERATURE

CARDIAC FAILURE

Cardiac failure is nowadays one of the common cause for IMCU admissions in any hospital. It is defined as the inability of the heart to pump sufficiently to maintain blood flow to meet the body's needs. There are numerous causes that lead on to cardiac failure such as Hypertension, Coronary Artery Heart Disease, Vavular Heart disease, Cardiomyopathy, Anemia, etc.

Many disease processes can impair the pumping efficiency of heart leading on to congestive heart failure[7] .Heart failure means the inability of the heart to adequately meet the needs of organs and tissues for oxygen and nutrients. This decrease in cardiac output is not enough to circulate the blood returning to the heart from the body and lungs leading to fluid leak from capillary blood vessels. This leads to the symptoms like breathing difficulty, weakness and swelling.

BLOOD CIRCULATION IN THE BODY:-

The right side of heart pumps blood to lungs for oxygenation[5] while left side pumps blood to rest of the body. Deoxygenated blood from the body enters the right atrium through superior and inferior vena cavae. Then it flows in to the right ventricle through tricuspid valve from where it is pumped into the lungs through the pulmonary artery. In the lungs it gets oxygenated, returns to the left atrium via 4 pulmonary veins .Then it enters left ventricle and distributed to the organs and tissues of the body[2] through aorta and its branches.

Oxygen enters RBCs, while Carbon-di-oxide an excretory product of metabolism is removed in the lungs. The cycle then repeats.

Left heart failure results when left ventricle is not able to pump blood to the body and fluid gets back logged, leaks in to the lungs causing breathlessness.Right heart failure occurs when right ventricle is not able to pump blood from the body in to the lungs for oxygenation. Blood and fluid gets back logged in the venous system, leading on to fluid leak into tissues and organs.

Both sides of the heart may fail at the same time leading on to biventricular heart failure.

Many disease entities can damage the pumping capacity of the heart leading on to CCF.

The most common causes for CCF are[6]

Coronary Artery Heart Disease

Hypertension

Chronic Alcoholism

Valvular Heart Disease

Toxic /Metabolic Diseases

Myocarditis

Congenital Heart Disease

Arrhythmias

Cardiomyopathy.

Less common causes are

Viral infections of heart muscle

Hypothyroidism and hyperthyroidism

Drug induced (NSAIDS , steroids, Pioglitazone, CCB)

Amyloidosis

Emphysema

Severe Anemia

Iron overload

Sarcoidosis

Causes of refractory cardiac failure

Silent MI

Pulmonary emboli

Thyrotoxicosis

LV aneurysm

Silent valvular stenosis

BeriBeri

Anemia

Myocarditis

Infection

Infective endocarditis

Cardiac tamponade

SA / AV nodal dysfunction

RISK FACTORS OF CHF[4]

It often results from atherosclerotic heart disease and hence the risk factors are the same.

Uncontrolled hypertension

Increased blood cholesterol

Diabetes

Smoking

Family history

Obstructive sleep apnoea

Alcohol

Drug abuse

Connective tissue disorders like SLE

Many patients will have a stable CHF that can decompensate on bodily changes. Suppose a patient with compensated CHF may be doing well but when something like respiratory infections or angina develops, it may precipitate heart failure. A decompensatory state may develop acutely when patient takes excessive liquid or salt or not taking his routine prescribed drugs.

PATHOPHYSIOLOGY

Low cardiac output leads to decreased perfusion and inadequate oxygen supply along with assosiated decreased cardiac reserve, pulmonary and systemic venous compliance.

Compensatory adaptation:-

1.Increase in left ventricular mass (LVH) and volume (dilatation)

2. Increased systemic vascular resistance

3.Activation of renin – angiotensin – aldosterone and vasopressin (ADH) system.

PRELOAD

Preload is the left ventricular end diastolic pressure and it depends on left ventricular compliance and venous return.

AFTERLOAD:-

Afterload is the left ventricular systolic wall tension that develops during ventricular systole and is determined by aortic valve resistance , peripheral vascular resistance and elasticity of major blood vessels.

CLASSIFICATION OF CARDIAC FAILURE

HIGH OUTPUT AND LOW OUTPUT FAILURE[2]

1.HIGH OUTPUT FAILURE

The heart is normal and it fails to maintain a normal or increased output during greatly increased demand situations like anemia, hyperthyroidism , Paget's disease ,A-V malformation , pregnancy. First, features of RVF appear , later LVF features become evident. The only clue to the development of LVF in patients with high output states is presence of shortened circulatory time.

2.LOW OUTPUT FAILURE

The heart fails to generate adequate output or can do so with high filling pressures.

The causes of low output failure are

i)Intrinsic heart muscle disease (Cardiomyopathy, IHD, Myocarditis, Chagas disease)

ii)Chronic excessive after load (Aortic stenosis , HTN)

iii)Chronic excessive preload (Mitral Regurgitation)

iv)Negative inotropic drugs (Anti arrhythmic agents)

v)Restricted filling (eg. Constrictive pericarditis or tamponade , restrictive cardiomyopathy)

vi)Extreme bradycardia (beta blockers , complete heart block)

RIGHT AND LEFT SIDED HEART FAILURE

1. RIGHT SIDED HEART FAILURE

Right sided heart failure is characterised by peripheral edema, abdominal discomfort (congestive hepatomegaly), raised JVP and hypotension. Usually there is no evidence of pulmonary edema.

2. LEFT SIDED HEART FAILURE

The classical feature of LVF is presence of pulmonary edema. Other signs are tachypnoea , tachycardia ,S3 ,pulsus alternans & cardiomegaly.

3.CONGESTIVE HEART FAILURE

Congestive heart failure has both the features of right and left sided heart failure.

FORWARD AND BACKWARD HEART FAILURE

1.FORWARD HEART FAILURE

Inadequate pumping of blood into the arterial system leads to poor tissue perfusion. Poor renal perfusion results in excessive sodium reabsorption through activation of Renin –Angiotensin-Aldosterone system.

2.BACKWARD HEART FAILURE

Due to the failure of one or the other ventricle to fill normally and discharge its contents, causing an elevated arterial and venous system pressure behind the failing ventricle.

SYSTOLIC AND DIASTOLIC FAILURE

1.SYSTOLIC FAILURE

Systolic failure occurs when there is inadequate cardiac output and usually associated with cardiomegaly. Patients with systolic failure are usually treated with ionotropic agents.

2.DIASTOLIC FAILURE

Diastolic failure is associated with increased resistance to ventricular inflow and reduced ventricular diastolic capacity. The patients are usually managed with vasodilator therapy.

NYHA (New York Heart Association) FUNCTIONAL CLASSIFICATION OF HEART FAILURE

CLASS	FUNCTIONAL CAPACITY
I	Patient without limitation of physical activity

II	Patient with slight limitation of physical capacity in which ordinary physical activity leads to fatigue, palpitation, dyspnoea or angina.
III	Patient with marked limitation of physical capacity in which, less than ordinary physical activity leads to symptoms of heart failure.
IV	Symptoms of heart failure even at rest.

CLINICAL FEATURES:-

Signs and symptoms include

Dyspnoea on exertion or dyspnoea at rest

Orthopnoea (while lying flat)

Paroxysmal nocturnal dyspnoea (May awaken person from sleep)

Acute pulmonary edema

Chest pain and palpitation

Tachycardia

Fatigue and weakness

Nocturia and oliguria

Anorexia , weight loss

Exophthalmos or visible pulsation of eye

Neck vein distension

Weak ,rapid and threading pulse

Rales , wheeze

S3 gallop +/- , pulsus alternans

Increased intensity of second heart sound

Hepato jugular reflex

Ascites ,hepatomegaly , anasarca

Cyanosis (central and peripheral) Pallor

RIGHT SIDED ♥ FAILURE

(Cor Pulmonale)


LEFT SIDED FAILURE
• Paroxysmal Nocturnal Dyspnea
• Elevated Pulmonary Capillary Wedge Pressure
• Pulmonary Congestion
- Cough
- Crackles
- Wheezes
- Blood-Tinged Sputum
- Tachypnea
• Restlessness
• Confusion
• Orthopnea
• Tachycardia
• Exertional Dyspnea
• Fatigue
• Cyanosis
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DIAGNOSIS:-

1. RELEVANT HISTORY

2. PROPER PHYSICAL EXAMINATION

3. INVESTIGATIONS

i) ECG

ECG helps to assess the heart rate, rhythm and indirectly the size of ventricles and blood flow to heart muscle.

ii) CHEST X-RAY

To look for heart size and presence or absence of fluid in the lungs

- Prominent upper lobe veins- pulmonary capillary wedge pressure >15mmHg
- Kerley B lines (engorged peripheral lymphatics seen in lower lobe PCWP >20mmHg
- Fluid in the fissures or interlobar effusion known as ‘phantom tumour’ as it disappears with treatment of left sided failure.

- Increase in bronchovascular markings, Chat's wing or inverted moustache signs- PCWP >25mmHg
- Pleural effusion – may be unilateral or bilateral
- Cardiomegaly

iii) BLOOD TESTS

CBC, electrolytes, glucose, BUN and creatinine (to assess kidney function)

iv) B TYPE NATRIURETIC PEPTIDE

This hormone is produced by right and left ventricular muscle cells and released in response to stretch, volume overload and elevated filling pressures. It is very specific and sensitive. It identifies or excludes heart failure. It is extremely useful in diagnosis, prognosis and monitoring the therapy. Serum levels of BNP is increased in heart failure and also in asymptomatic LV dysfunction. BNP level < 100pg/ml excludes cardiac failure.

Uric acid, CRP, trop I andT, TNF receptors are other biomarkers of heart failure.

v) ECHOCARDIOGRAPHY

To assess the anatomy and function of the heart. It can assess blood flow of the heart, chamber enlargement, contractility and measures ejection fraction.

vi) ANGIOGRAPHY

4. FRAMINGHAM CRITERIA FOR DIAGNOSIS OF CCF

MAJOR CRITERIA:-

PND

Neck vein engorgement

Crackles-lung field

Cardiomegaly

Acute pulmonary edema

S3 gallop

Increase venous pressure (>16cm H2O)

Positive hepato jugular reflex

MINOR CRITERIA

Extremity edema

Nocturnal cough

Dyspnoea on exertion

Pleural effusion

Tachycardia (120 bpm)

Decreased vital capacity by 1/3

MAJOR/ MINOR CRITERIA

5 days treatment causing weight loss > or equal to 4.5 kg

FOR DIAGNOSIS: 1 MAJOR +2 MINOR

TREATMENT OF CARDIAC FAILURE:-

GENERAL PRINCIPLES OF MANAGEMENT:-

1. Removal of precipitating causes:-

Like anemia, arrhythmia, pregnancy, infection, thyroid disorders,smoking and alcohol ,drugs, hypertension, MI, pulmonary embolism ,dietary and medical non compliance.

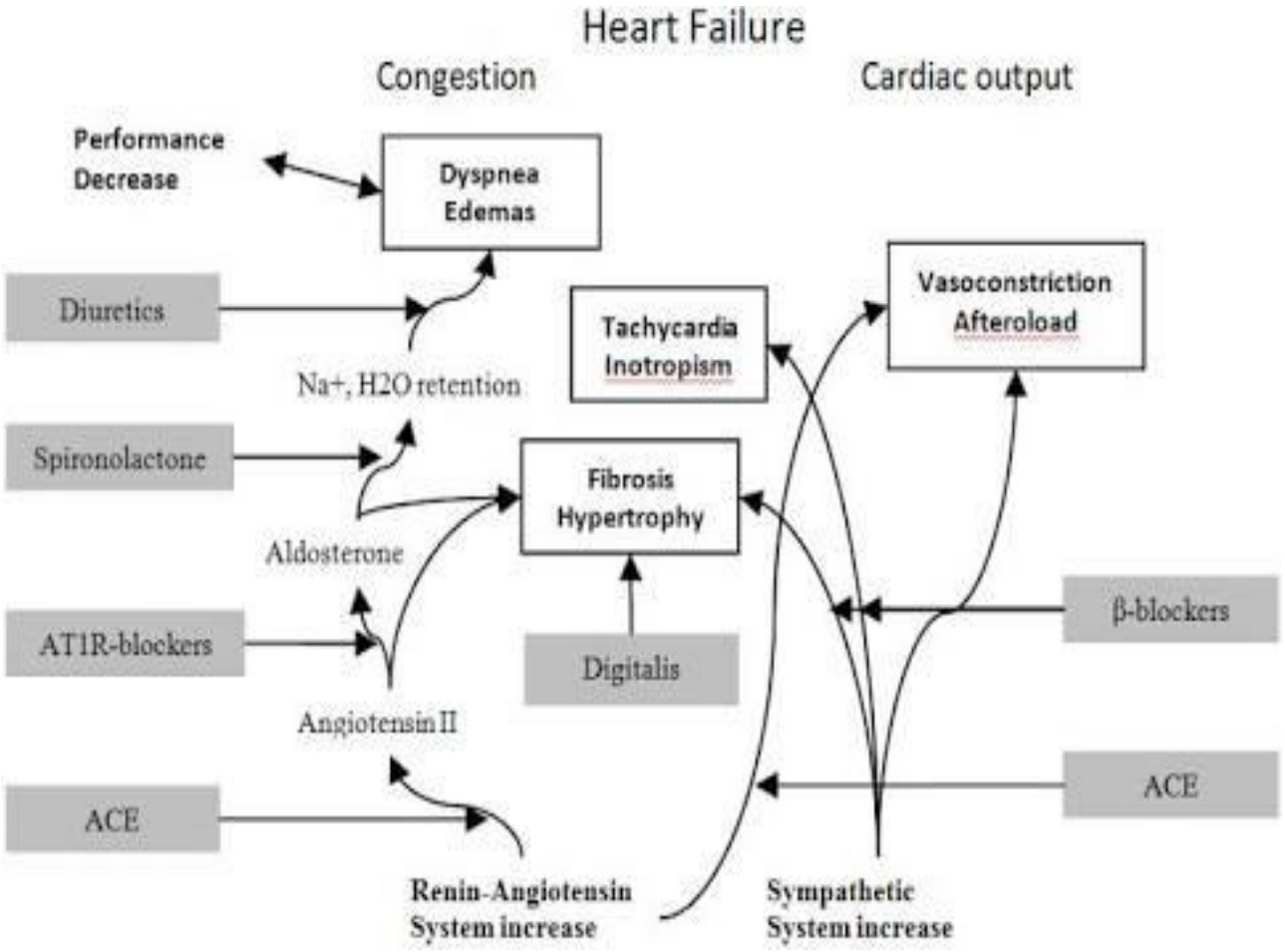
2. Correction of underlying causes like CHD, RHD.

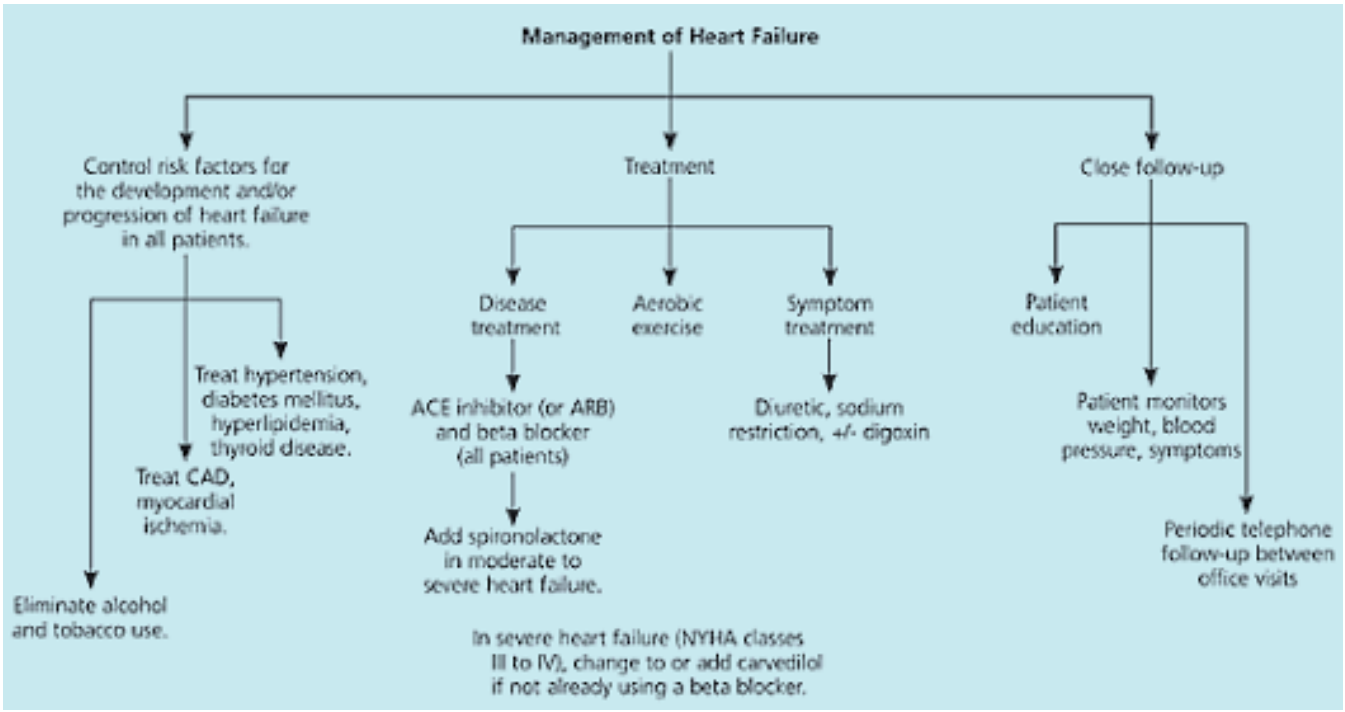
3. Control of fluid and sodium retention.

4. Enhancement of myocardial contractility.

5. Reduction of pulmonary and systemic venous congestion.

6. Minimisation of cardiac work load.


Heart Failure
Congestion
Cardiac output
Performance Decrease
Dyspnea Edemas
Diuretics
Na+, H2O retention
Spironolactone
Aldosterone
AT1R-blockers
Angiotensin II
ACE
Renin-Angiotensin System increase
Tachycardia Inotropism
Vasoconstriction Afteroload
Fibrosis Hypertrophy
Digitalis
β-blockers
ACE
Sympathetic System increase


Management of Heart Failure
Control risk factors for the development and/or progression of heart failure in all patients.
Treatment
Close follow-up
Treat hypertension, diabetes mellitus, hyperlipidemia, thyroid disease.
Treat CAD, myocardial ischemia.
Eliminate alcohol and tobacco use.
Disease treatment
Aerobic exercise
Symptom treatment
ACE inhibitor (or ARB) and beta blocker (all patients)
Add spironolactone in moderate to severe heart failure.
Diuretic, sodium restriction, +/- digoxin
In severe heart failure (NYHA classes III to IV), change to or add carvedilol if not already using a beta blocker.
Patient education
Patient monitors weight, blood pressure, symptoms
Periodic telephone follow-up between office visits

In this study we are dealing with coronary artery heart disease and rheumatic heart disease patients who were recovered from cardiac failure. Hence we discuss a few points from coronary artery heart disease and rheumatic heart disease.

CORONARY ARTERY HEART DISEASE:-

Coronary artery heart disease is one of the important causes for cardiac failure. It comprises a group of diseases which vary from stable angina, unstable angina, myocardial infarction to sudden cardiac death.

One third of all deaths globally were due to coronary artery heart disease. Nearly 7.6 million deaths annually are attributed to coronary artery heart disease. By 2030 researchers project that CAHD alone will be the cause of more deaths than infectious diseases in developing and under developed countries.

Chest pain is the most common symptom of CAHD which is compressive in nature felt retrosternally radiating to shoulder, arm, jaw, and epigastric region getting aggravated on exertion relieved by taking rest or

nitrates. Other symptoms include fatigue, breathlessness, syncope and palpitation.

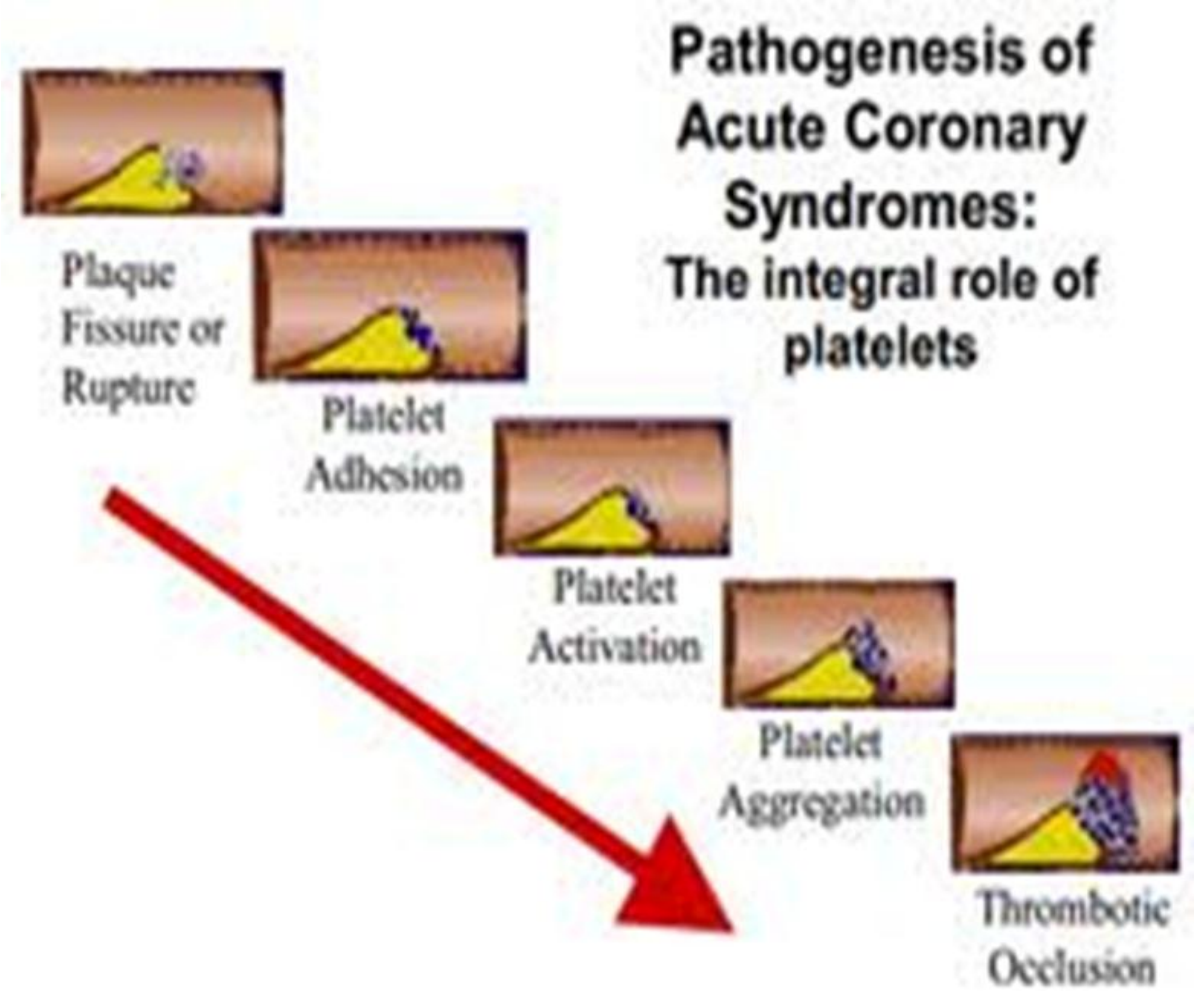
Risk factors for CAHD are

1. Hypertension
2. Diabetes mellitus
3. Smoking
4. Alcohol
5. Sedentary life style
6. Obesity
7. Hyperlipidemia
8. Depression

PATHOPHYSIOLOGY:-

Decreased blood flow to the cardiac muscle fibres causes ischemia of the myocardial cells. These cardiac cells may die due to lack of oxygen and this is called myocardial infarction which leads to heart muscle death , myocardial scarring without heart muscle regrowth. Atherosclerosis when

develops within the smooth elastic lining inside the coronary artery leads to CAHD. Due to the same, the inner wall of the artery hardens, stiffens and swollen with calcium deposits, fatty deposits, certain inflammatory cells to form the plaque. Rupture of these plaques cause contact between coagulation factors of blood and thrombogenic tissue factor which is expressed by macrophage foam cells. If a thrombus formed due to this mechanism is non occlusive, an episode of plaque disruption sometimes does not cause symptoms or otherwise causes episodic ischemic features. Occlusive thrombi in the absence of collaterals supplying coronary artery causes acute myocardial infarction.



DIAGNOSIS:-

CAHD can be diagnosed using following investigations

1.Electrocardiogram(ECG)

2.Echocardiogram

3.Cardiac enzymes

4.Stress test

5.Cardiac catheterization or Angiogram

6.Heart scan

7.Magnetic resonance angiogram

TREATMENT:-

Treatment for CAHD include

1.PCI

2.Antifibrinolytics such as streptokinase and urokinase

3. Injection Heparin

4.T.Aspirin

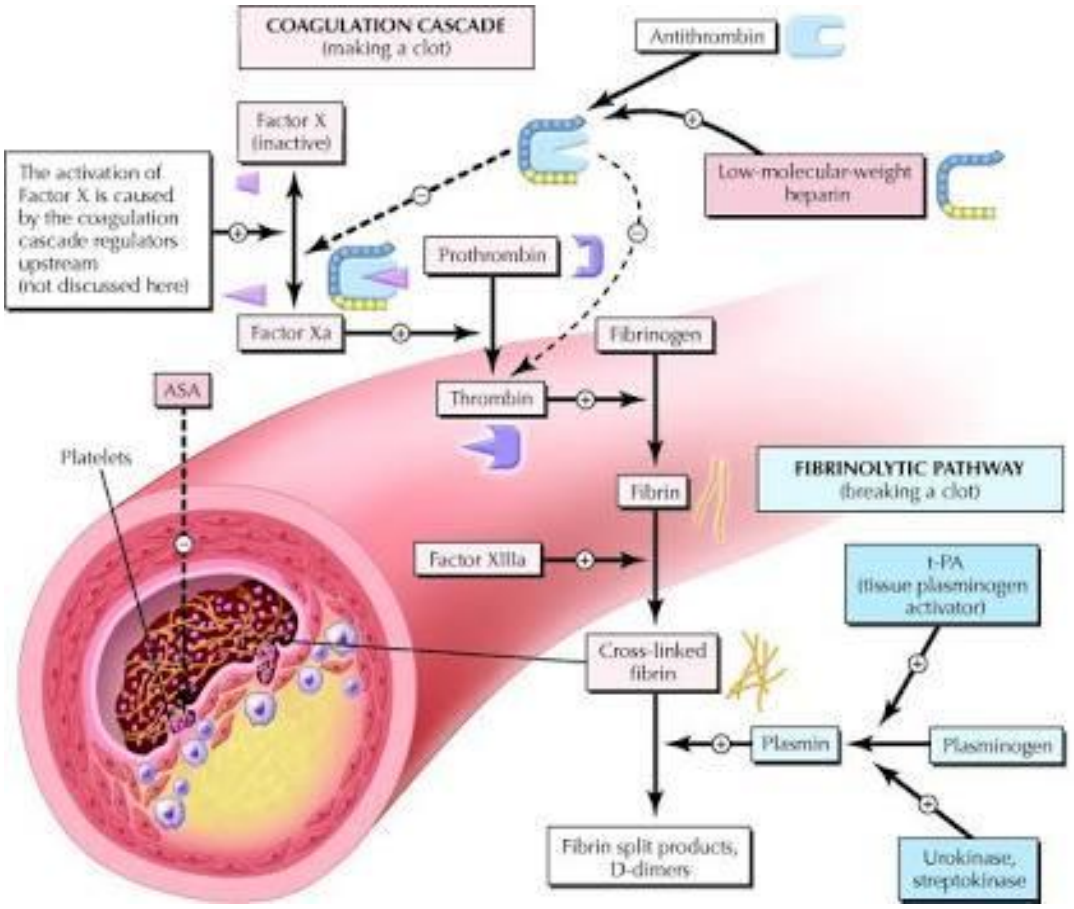
5.T.Clopidogrel

6.T.Atorvastatin

7.T.Sorbitrate

8.ACE inhibitors like T. Enalapril, T.Ramipril etc.

9.Beta blockers like T.Carvedilol , T.Bisoprolol and T.Metaprolol

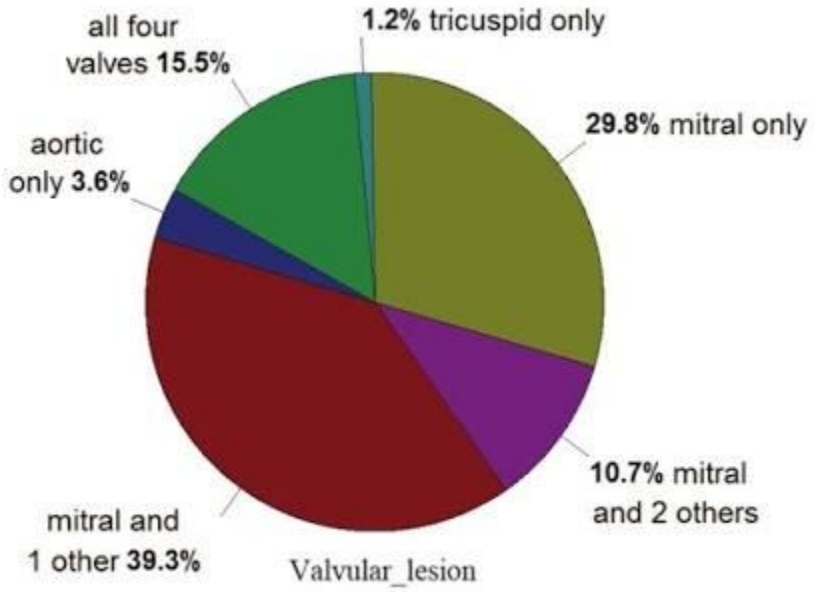


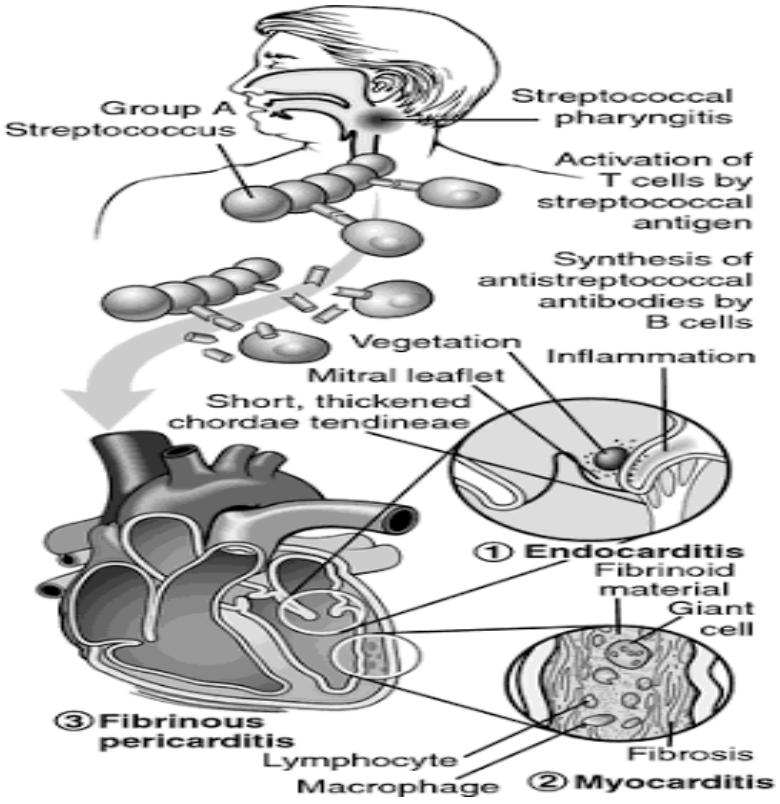
RHEUMATIC HEART DISEASE

RHD which is the most common cause of heart disease in children globally, results in permanent damage to the heart specifically heart valves following rheumatic fever .The most common valves affected in RHD are mitral valve and aortic valve . Despite its declining trend it still

causes a heavy burden in the social and economic life in developing countries.

Acute rheumatic fever is a post infectious sequelae of pharyngitis caused by group A beta hemolytic streptococci . Risk factors of rheumatic fever includes overcrowding , poor sanitation and other conditions causing multiple exposure to streptococcus bacteria.




Group A
Streptococcus
Streptococcal
pharyngitis
Activation of
T cells by
streptococcal
antigen
Synthesis of
antistreptococcal
antibodies by
B cells
Vegetation
Inflammation
Mitral leaflet
Short, thickened
chordae tendineae
① Endocarditis
Fibrinoid
material
Giant
cell
③ Fibrinous
pericarditis
Lymphocyte
Macrophage
Fibrosis
② Myocarditis

CLINICAL FEATURES:-

Clinical features of rheumatic fever may vary which includes

1. Fever
2. Migrating painful joints
3. Red hot inflamed joints
4. Small painless subcutaneous nodules
5. Chest pain
6. Painless ragged raised rash
7. Uncontrollable semi purposeful abnormal movements
8. Unusual behavior such as inappropriate laughter and crying

DIAGNOSIS

Diagnosis of rheumatic fever is based on revised Jones criteria, which says two major or one major and two minor criteria associated with evidence of group A streptococcal infection can be diagnosed as rheumatic fever.

MAJOR CRITERIA

1. Pancarditis
2. Migrating polyarthritis involving major joints
3. rheumatic chorea (syndenham's)
4. Erythema marginatum
5. Subcutaneous nodules

MINOR CRITERIA

1. Fever
2. Polyarthralgia
3. Elevated ESR and leucocyte count
4. Prolonged PR interval in ECG
5. elevated CRP

SUPPORTING EVIDENCE

1. Elevated anti streptolysin O titre
2. Positive throat culture

3. Rapid antigen test for group A streptococcus

4. Recent scarlet fever

TREATMENT:-

The treatment for acute rheumatic fever includes Injection Crystalline Penicillin 1.0 million units i.v 4-6th hourly for 1 week or tablet Penicillin 500 mg (250 mg for children) per oral twice daily with tablet Aspirin 80 to 100 mg/ kg per day for two weeks. The use of glucocorticoids in acute rheumatic fever remains controversial.

PROPHYLAXIS:-

Prophylaxis is given by injection Benzathine Penicillin 1.2 million units deep im (6 lakh units if less than 27 kg) under the following schedule.

1. Without carditis –5 years following last attack or age 21 whichever is longer

2. With carditis but no residual valvular lesion- 10 years following last attack or age 21 whichever is longer.

3. Persistent valvular lesion- lifelong .

LUNG FUNCTION TESTS

Lung function tests[9] measure how lungs take in air and exhale and also how efficiently they transfer oxygen into the blood. There are a lot of tests included in Pulmonary function tests.It is a generic term used to indicate a battery of studies or manoeuvres that may be performed using standardized equipment to measure lung function.

It evaluates one or more aspects of the respiratory system

– Respiratory mechanics

– Lung parenchymal function/ Gas exchange

– Cardiopulmonary interaction

Pulmonary function tests can be classified broadly into

MECHANICAL/ VENTILATORY FUNCTIONS OF LUNG / CHEST WALL

- BED SIDE PULMONARY FUNCTION TESTS
- STATIC LUNG VOLUMES & CAPACITIES – VC, IC, IRV, ERV, RV,FRC.
- DYNAMIC LUNG VOLUMES –FVC, FEV1, FEF 25-75%,

PEFR, MVV, RESP. MUSCLE STRENGTH

GAS- EXCHANGE TESTS

- ALVEOLAR-ARTERIAL PO2 GRADIENT
- DIFFUSION CAPACITY
- GAS DISTRIBUTION TESTS-

1) SINGLE BREATH N_2 TEST.

2) MULTIPLE BREATH N_2 TEST

3) HELIUM DILUTION METHOD

4) RADIO Xenon SCINITIGRAM

SPIROMETRY: CORNERSTONE OF ALL PFTs.

John hutchinson – invented spirometer.

"Spirometry is a medical test that measures the volume of air an individual inhales or exhales as a function of time."

CAN'T MEASURE – FRC, RV, TLC

The main gadget used in pulmonary function testing is the spirometer. It is designed to measure changes in volume and can only measure lung volume in chambers that exchanges gas with the atmosphere. Spirometers with electronic signal outputs (pneumotachs) also measure flow (volume per unit of time). A device is usually always attached to the spirometer which measures the movement of gas in and out of the chest and is referred to as a spirograph. Sometimes the spirograph is replaced by a printer like unit. The resulting tracing is called a spirogram. Many computerized systems have complex spirographs or printouts that show the predicted values next to the observed values (the values actually measured). The unit will have in memory all of the prediction tables for males and females across all age groups. In special spirometers, there are special tables

of normal values programmed into the machine for selection when Blacks, children or other groups are being tested who may vary from the normal PFT tables established for caucasian adults.

There are a few variables such as age, gender and body size which may have an impact on the lung function of one individual compared to another.

INDICATIONS FOR SPIROMETRY[12]

1.DETECTING PULMONARY DISEASE

History of pulmonary symptoms

- Chest pain or orthopnea
- Cough or phlegm production
- Dyspnea or wheezing

Physical findings

- Chest wall deformities
- Cyanosis
- Decreased respiratory sounds
- Finger clubbing

Abnormal laboratory findings

- Abnormal blood gas analysis

Abnormal Chest xray

2.ASSESSING SEVERITY OR PROGRESSION OF DISEASE

Pulmonary diseases

Chronic obstructive pulmonary disease

Cystic fibrosis

Interstitial lung diseases

Sarcoidosis

Cardiac diseases

Congestive heart failure

Congenital heart disease

Pulmonary hypertension

Neuromuscular diseases

Amyotrophic lateral sclerosis

Guillain-Barré syndrome

Multiple sclerosis

Myasthenia gravis

3.RISK STRATIFICATION OF PATIENTS FOR SURGERY

Thoracic surgeries

Lobectomy

Pneumonectomy

Cardiac surgeries

Coronary bypass

Correction of congenital abnormalities

Valvular surgery

Organ transplantation

General surgical procedures

Cholecystectomy

Gastric bypass

4. EVALUATING DISABILITY OR IMPAIRMENT

Social Security or other compensation programs

Legal or insurance evaluations

CONTRAINDICATIONS OF SPIROMETRY

Acute disorders affecting test performance (e.g.,vomiting, nausea, vertigo)

Hemoptysis of unknown origin (FVC maneuver may aggravate underlying condition.)

Pneumothorax

Recent abdominal or thoracic surgery

Recent eye surgery (increases in intraocular pressure during spirometry)

Recent myocardial infarction or unstable angina

Thoracic aneurysms (risk of rupture because of increased thoracic pressure)

FACTORS AFFECTING SPIROMETRY VALUES[10]

Age:

The natural elasticity of the lungs decreases with age. As age increases lung volumes and capacities become smaller and smaller. So it is important to compare the results of a normal person of the same age and gender while interpreting spirometry values.

Gender:

Usually males have more lung volumes and capacities compared to females even when they are matched for height and weight. Because of this difference in lung volumes and capacities, different normal tables must be used for males and females.

Body Height &Size:

Body size has huge effects on PFT values.The PFT result of a small man will be smaller than a man of the same age who is much larger. Normal tables give predicted PFT data for males or females of a certain age and height by accounting for this variable .As people age they begin to increase their body mass by increasing their body fat to lean body mass ratio. The abdominal mass prevents the diaphragm from descending as far as it could

and the PFT results will be below the expected PFT values - i.e. the observed (measured)values are actually smaller than the predicted values (predicted values from the normal tables) if they become too obese.

Race:

The PFT values are affected by race also. Blacks, Hispanics and Native Americans have different PFT results compared to Caucasians. Hence while interpreting PFT values of a patient , we should use a race appropriate table to compare the patient's measured pulmonary function against the results of the normal table written for that patient's racial group.

The degree of effect on PFT is not clearly understood for other factors such as environmental factors and altitude but may have effect on PFT.

PREPARING THE PATIENT

The patientsshould be comfortable and they should be seated since there is a chance of faintness or syncope during the procedure. Before doing

the test the purpose of the test should be explained to the patient .Ideally the correct technique is demonstrated before asking the patient to use a spirometer for the first time. And ask the patient to have some practice sessions before the readings are taken. Encourage the patient to keep blowing out so that maximal exhalation can be achieved. The total number of times the patient takes for practice and recording is limited to eight or less at each session.

SPIROMETRIC VALUES

Lung function is physiologically divided into four volumes: expiratory reserve volume, inspiratory reserve volume, residual volume, and tidal volume. The sum of all these four volumes make the total lung capacity (TLC). Lung volumes and their combinations measure various lung capacities such as functional residual capacity(FRC), inspiratory capacity, and VC.[11]

FVC - Forced Vital Capacity :-

This is the volume of air which can be forcibly and maximally exhaled out of the lungs after a deep inspiration . FVC is usually expressed in units called liters. This PFT value is very significant in the diagnosis of obstructive and restrictive diseases.

FEV1 - Forced Expiratory Volume in One Second

This is the amount of air which can be forcibly exhaled from the lungs in the first second of a forced expiratory manoeuvre. It is expressed as litres This PFT value is very significant in the diagnosis of obstructive and restrictive diseases.

FEV1/FVC - FEV1 Percent (FEV1%)

This measurement is the ratio of FEV1 to FVC - it indicates what percentage of the total FVC was expelled from the lungs during the first second of forced exhalation - this number is called FEV1%, %FEV1 or FEV1/FVC ratio. This value helps in the diagnosis of obstructive and restrictive diseases.

FEV3 - Forced Expiratory Volume in Three Seconds

This is the volume of air which can be forcibly exhaled in three seconds - measured in Litres - this volume usually is almost close to the FVC, since in the normal individual most of the air in the lungs can be forcibly exhaled in three seconds.

FEV3/FVC - FEV3%

This number is the ratio of FEV3 to the FVC - it indicates what percentage of the total FVC was expelled during the first three seconds of forced exhalation. This is called %FEV3 or FEV3%.

PEFR - Peak Expiratory Flow Rate

This is maximum flow rate achieved by the patient during the forced vital capacity manoeuvre beginning after full inspiration and starting and ending with maximal expiration - it can either be measured in L/sec or L/min - this is a useful measure to see if the treatment is improving obstructive diseases like bronchoconstriction due to asthma.

FEF - Forced Expiratory Flow

Forced expiratory Flow is a measure of how much air can be expired from the lungs. It is a flow rate measurement. It is measured as liters/second

or liters/minute. The FVC expiratory curve is divided into quartiles and therefore there is a FEF that existsfor each quartile. The quartiles are expressed as FEF25%, FEF50%, and FEF75% of FVC.

FEF25%

This measurement describes the amount of air that was forcibly expelled in the first 25% of the total forced vital capacity test.

FEF50%

This measurement describes the amount of air expelled from the lungs during the first half (50%) of the forced vital capacity test. This test is useful when looking for obstructive disease.The amount of air that will have been expired in an obstructed patient is smaller than that measured in a normal patient.

FEF25%-75%

This measurement describes the amount of air expelled from the lungs during the middle half of the forced vital capacity test. Many physicians like to look at this value because it is an indicator of obstructive disease.

MVV - Maximal Voluntary Ventilation: -

This value is determined by having the patient breathe in and out as rapidly and fully as possible for 12 -15 seconds - the total volume of air moved during the test. Usually expressed as L/sec or L/min . The value helps to assess the status of the respiratory muscles, compliance of the thorax-lung complex, and airway resistance. Drawback of the test is that it is effort dependant and therefore can be a poor predictor of true pulmonary strength and compliance.

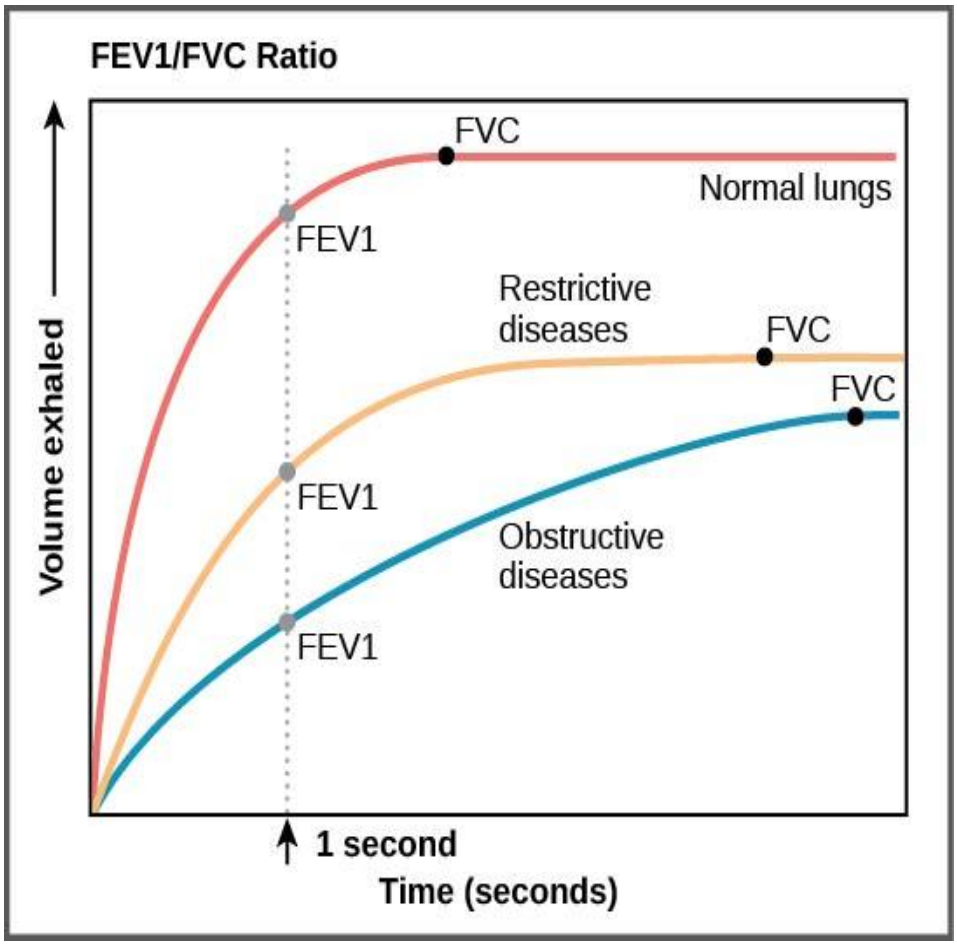
MEASURMENT OF FEV_1 AND FVC

To measure the values first attach a disposable, clean, one-way mouthpiece to the spirometer (a fresh one for each patient) and the patient is asked to breathe in as deeply as possible (full inspiration).

The patient should hold their breath just long enough to seal their lips. The patient should NOT purse their lips as if blowing a trumpet, and ideally should pinch their nose or wear a nose clip. The patient should now blow the breath out, forcibly, as hard and as fast as possible, until there is nothing left to expel.

Patient should be encouraged to keep blowing out. Some spirometers give a beep to confirm the manoeuvre is complete. Now repeat the procedure two times.

Ideally three readings should be obtained of which the best two which are within 100ml, or 5%, of each other. Depending on model of spirometer the results may be displayed or directly printed into a strip.



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

• FEV1 <80% predicted normal

• FVC <80% predicted normal

• FEV1/FVC ratio <0.7

Obstructive disorder:

• FEV1 decreased (<80% predicted normal)

• FVC is usually found to be reduced but to a smaller extent than FEV1

• FEV1/FVC ratio decreased (<0.7)

Restrictive disorder:

• FEV1 decreased(<80% predicted normal)

• FVC decreased (<80% predicted normal)

• FEV1/FVC ratio normal (>0.7)

MEASURING VITAL CAPACITY (VC)

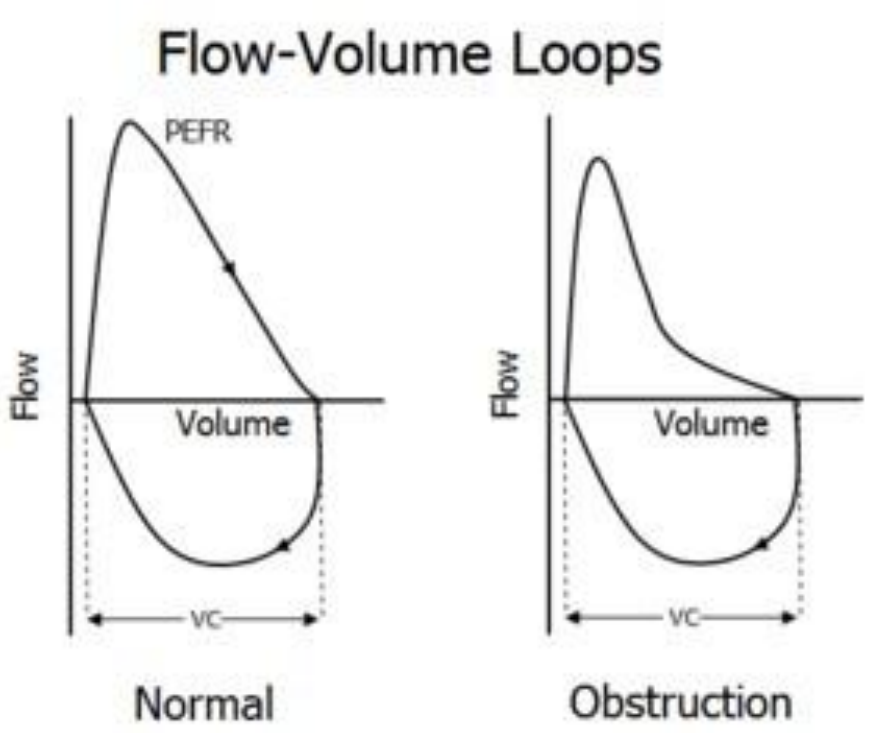
The VC is a non-forced manoeuvre and usually greater than the FVC in COPD. It shows more accurate measurement of lung volume when airways are floppy, as in emphysema. It is usually calculated at the beginning of the procedure to understand the patient with the equipment.

- a fresh ,new, clean, disposable, one-way mouthpiece is attatched to the spirometer
- patient should breathe in as deeply as possible (in full inspiration).
- Patient is asked to hold their breath just long enough to seal their lips. The patient should NOT purse their lips as if blowing a trumpet, and ideally should pinch their nose or wear a nose clip.
- Breathe out steadily, slowly at a comfortable pace.
- Continue until expiration is complete.

- The measurement of slow VC may allow the assessment of airflow obstruction in patients who are unable to perform a forced measurement to full exhalation.

FLOW-VOLUME MEASUREMENT

Spirometers can measure expiratory flow plotted against the volume of air exhaled. The graph produced is called a flow-volume curve. The overall shape of the flow-volume curve is helpful for detecting airflow obstruction at an early stage, and yields additional information to the volume-time curve. However, interpretation of the flow-volume curve must take into account the values of FEV1 and FVC (as a % of predicted normal).



Normal flow-volume curves

On exhalation, there is a fast rise to the maximal expiratory flow continued by a steady, uniform decrease until all the air is exhaled.

Obstructive disorder:

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

Severe obstructive disorder:

In a severe airflow obstruction, especially with emphysema, the characteristic ‘steeple pattern’ is seen in the expiratory flow graph.

Restrictive disorder:

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

There are many studies done globally in assessing the pulmonary function test in cardiac patients .Certain studies indicated impaired pulmonary function is common in cardiac patients but more deterioration

was found as a complication following coronary artery bye pass graft surgery rather than CAHD and RHD . Respiratory muscle weakness was documented in various studies in rheumatic valvular heart disease such as mitral stenosis .

MATERIALS AND METHODS

This study is a observational study conducted in Department of Medicine, Tirunelveli Medical College Hospital. Seventy five patients admitted in TVMCH from MAY 2014 to MAY 2015 will participate in the study. The volunteer patients who met the inclusion criteria, signed a consent form after they got a clear explanation of the spirometry evaluation procedures.

Inclusion Criteria :

- Adult patients with Rheumatic Heart Disease (Male and Female)
- Coronary artery heart disease patients less than 60 years of age (Male and Female)

Exclusion Criteria :

- Pediatric patients less than 12 years of age and Adult patients more than 60 years of age
- Rheumatic Heart disease patients with known respiratory disease (COPD, BronchialAsthma, Pulmonary Tuberculosis)
- CAHD patients with known respiratory disease(COPD, BronchialAsthma,Pulmonary Tuberculosis)
- Morbid and sick patients

- Severe Left Ventricular Dysfunction patients as per ECHO report.

DATA COLLECTION

- Detailed medical history and physical examination will be done
- Basic Laboratory investigations such as complete blood count , RFT and Urine analysis done
- ECG
- X-Ray Chest PA view
- Echocardiogram
- Spirometry test

SPIROMETER

The spirometry is performed using a device called a spirometer,which comes in several different varieties. Most spirometers display the following graphs,calledspirograms:

- A volume-time curve, showing volume (liters)along the Y-axis and time (seconds) along the X-axis
- A flow-volume loop,which graphically depicts the rate of airflow on the Y-axis and the total volume inspired or expired on the X-axis

PROCEDURE

The basic forced volume vital capacity (FVC) test varies slighty depending on the equipment used.

Generally, the patient is asked to take the deepest breath they can, and then exhale into the sensors hard as possible, for as long as possible, preferably at least 6 seconds. It is sometimes directly followed by a rapid inhalation(inspiration),in particular when assessing possible upper airway obstruction. Sometimes, the test will be preceded by a period of quiet breathing in and out from the sensor (tidal volume) or the rapid breath in (forced inspiratory part) will come before the forced exhalation.

During the test, soft nose clips may be used to prevent air escaping through the nose. Filter mouthpieces may be used to prevent the spread of microorganisms.

LIMITATIONS OF TEST

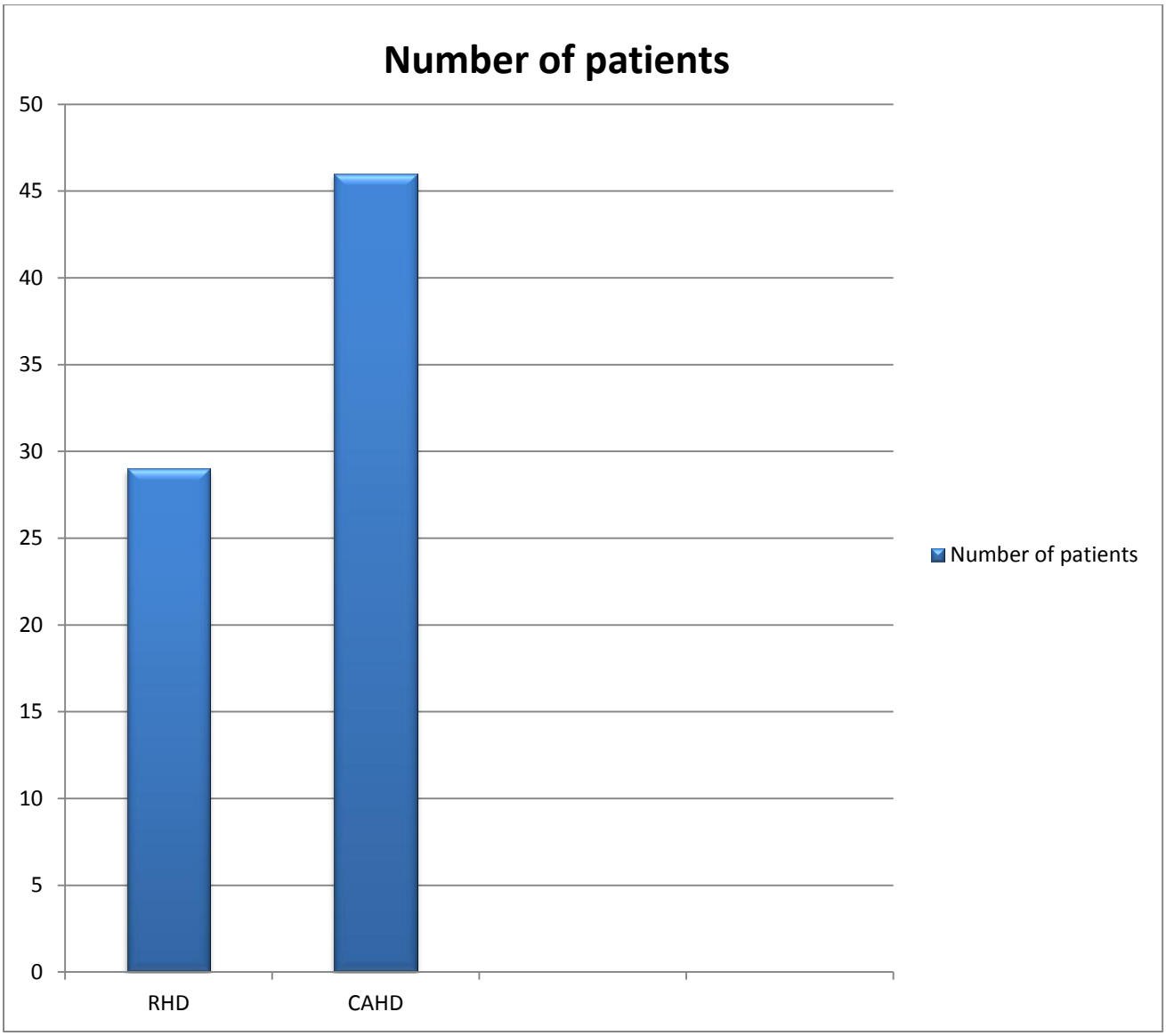
The manoeuvre is highly dependent on patient cooperation and effort, and is normally repeated at least three times to ensure reproducibility. Since results are dependent on patient cooperation, FVC can only be underestimated, never overestimated.

Due to the requirement of patient cooperation , spirometry can only be used on children old enough to comprehend and follow the instructions given(6 years old or more),and only on patient who are able to understand and follow instructions- thus, this test is not suitable for patients who are unconscious ,heavily sedated ,or have limitations that would interfere with vigorous respiratory efforts. Other types of lung function tests are available for infants and unconscious persons.

Another major limitation is the fact that many intermittent or mild asthmatics have normal spirometry between acute exacerbation, limiting spirometry's usefulness as a diagnostic tool. It is more useful as a

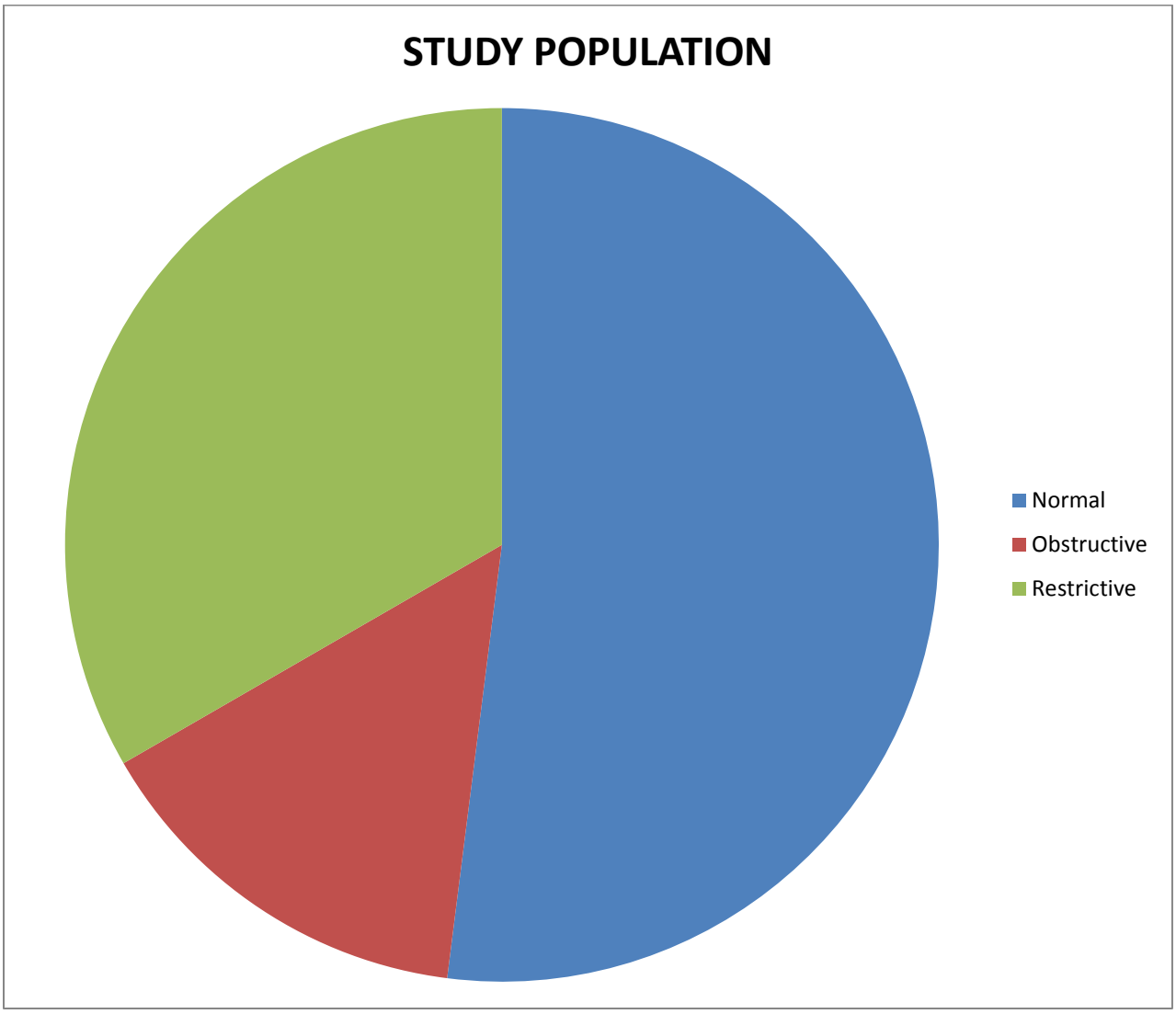
monitoring tool. A sudden decrease in FEV1 or other spirometric measure in the same patient can signal worsening,even if the raw value is still normal. Patients are encouraged to record their personal best measures .

OBSERVATIONS AND RESULTS


Number of patients
50
45
40
35
30
25
20
15
10
5
0
RHD
CAHD
Number of patients

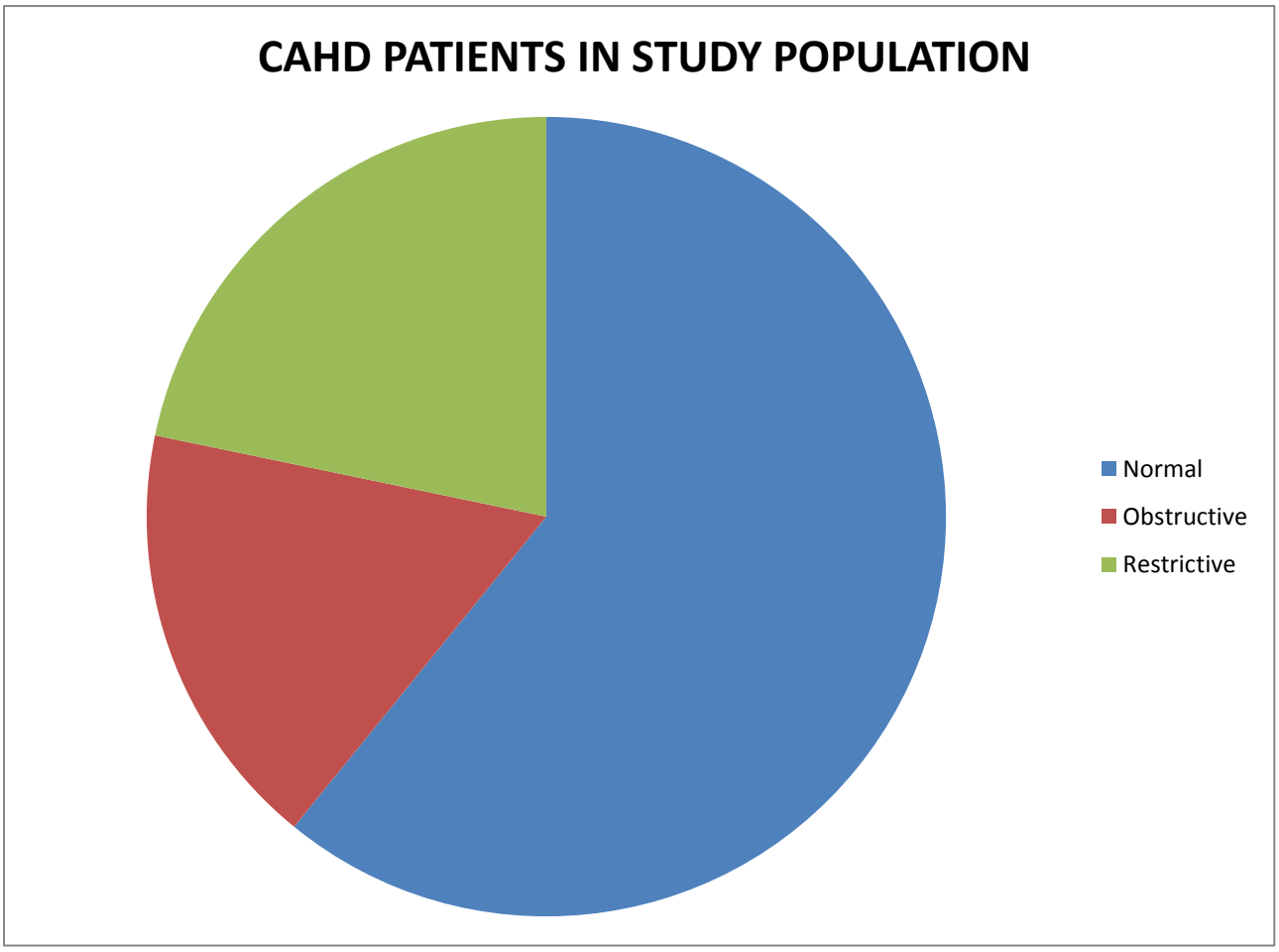
	MALE	FEMALE	TOTAL
CAHD	28	18	46
RHD	21	8	29
TOTAL	49	26	75

Among the 75 patients under study, 49 were male and 28 were female patients. Out of 49 male patients, 28 were having CAHD and 21 were suffering from rheumatic heart disease. Among the 26 females, 18 were found to have CAHD and 8 were suffering from rheumatic heart disease.


STUDY POPULATION
Normal
Obstructive
Restrictive

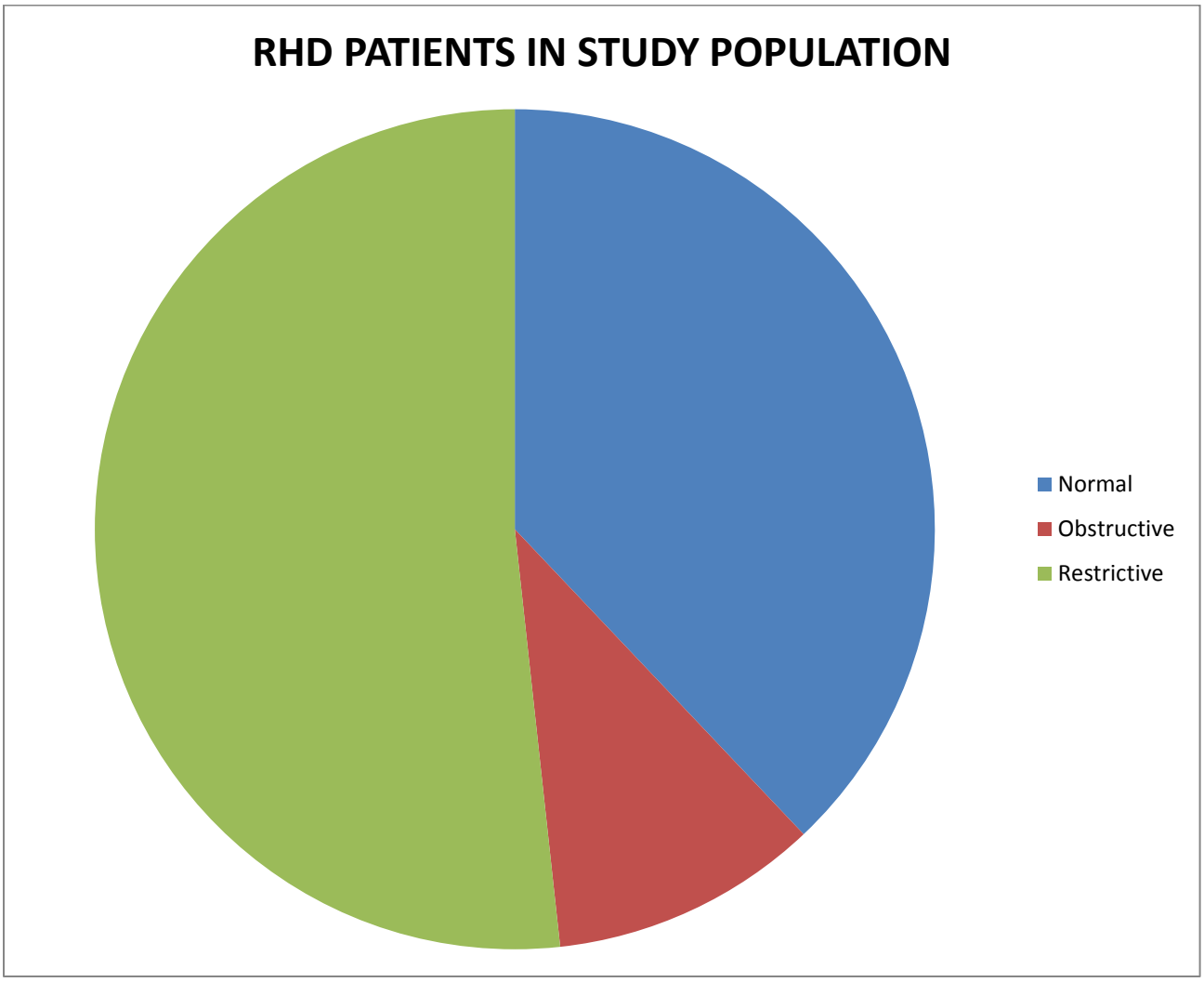
	MALE	FEMALE	TOTAL
NORMAL	26	13	39
OBSTRUCTIVE	8	4	12
RESTRICTIVE	15	9	24
TOTAL	49	26	75

Among 49 males in study population 26 were found to have normal pulmonary function test parameters, 15 showed restrictive pattern and 8 showed obstructive pattern. Out of 26 females 13 were found to have normal pattern , 9 showed restrictive pattern and 4 were found to have obstructive pattern. Among total 75 pateints, 39 patients showed normal pft pattern,24 showed restrictive pattern in pft and 12 were found to have obstructive pattern.


CAHD PATIENTS IN STUDY POPULATION
Normal
Obstructive
Restrictive

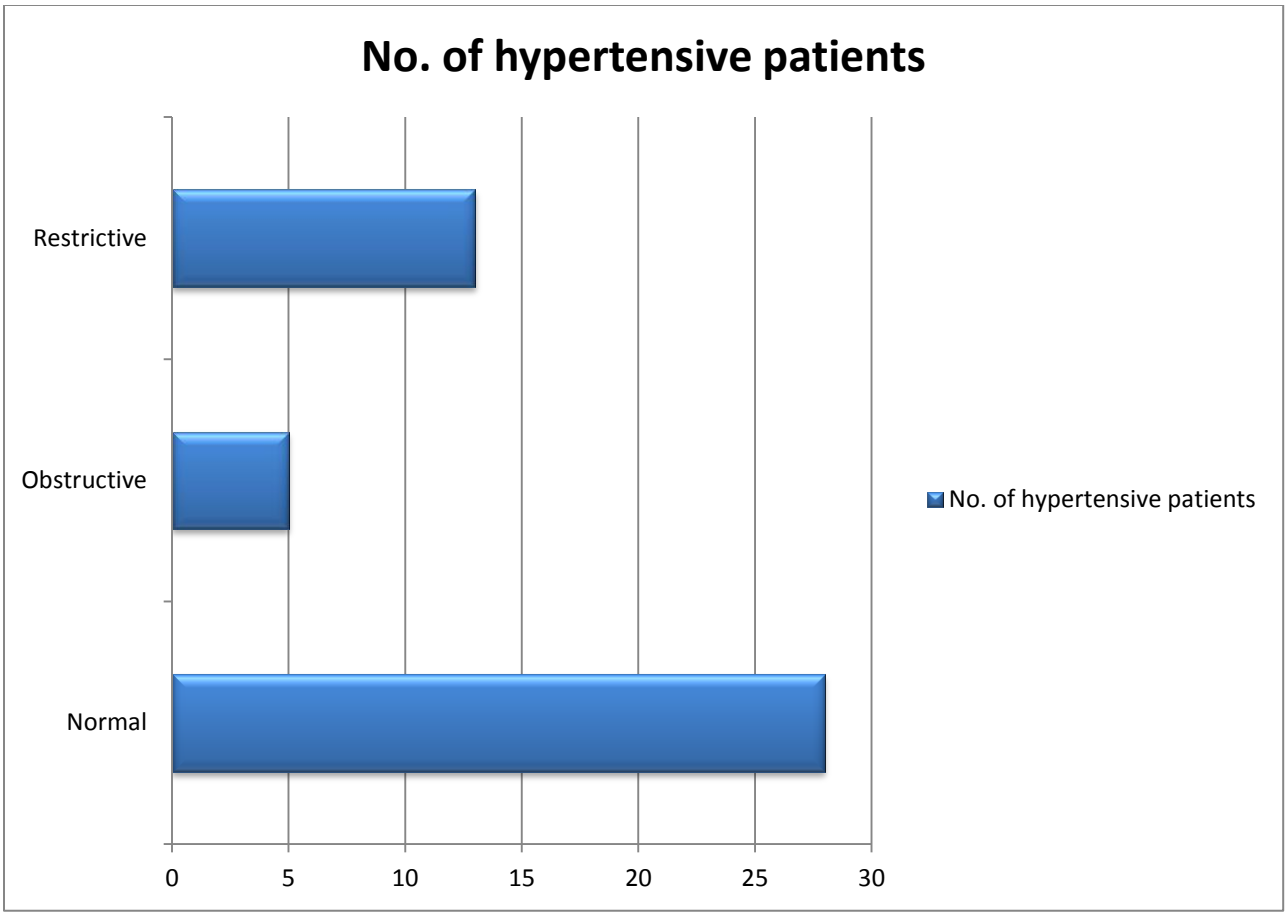
	MALE	FEMALE	TOTAL
NORMAL	18	10	28
OBSTRUCTIVE	5	3	8
RESTRICTIVE	5	5	10
TOTAL	28	18	46

46 patients among the study population were CAHD patients. Among them 28 were males and 18 were females. Among 28 males, 18 were having normal PFT pattern, 5 showed obstructive pattern and 5 showed restrictive pattern. Among 18 females, 10 showed normal pattern ,3 showed obstructive pattern and 5 showed restrictive pattern.


RHD PATIENTS IN STUDY POPULATION
Normal
Obstructive
Restrictive

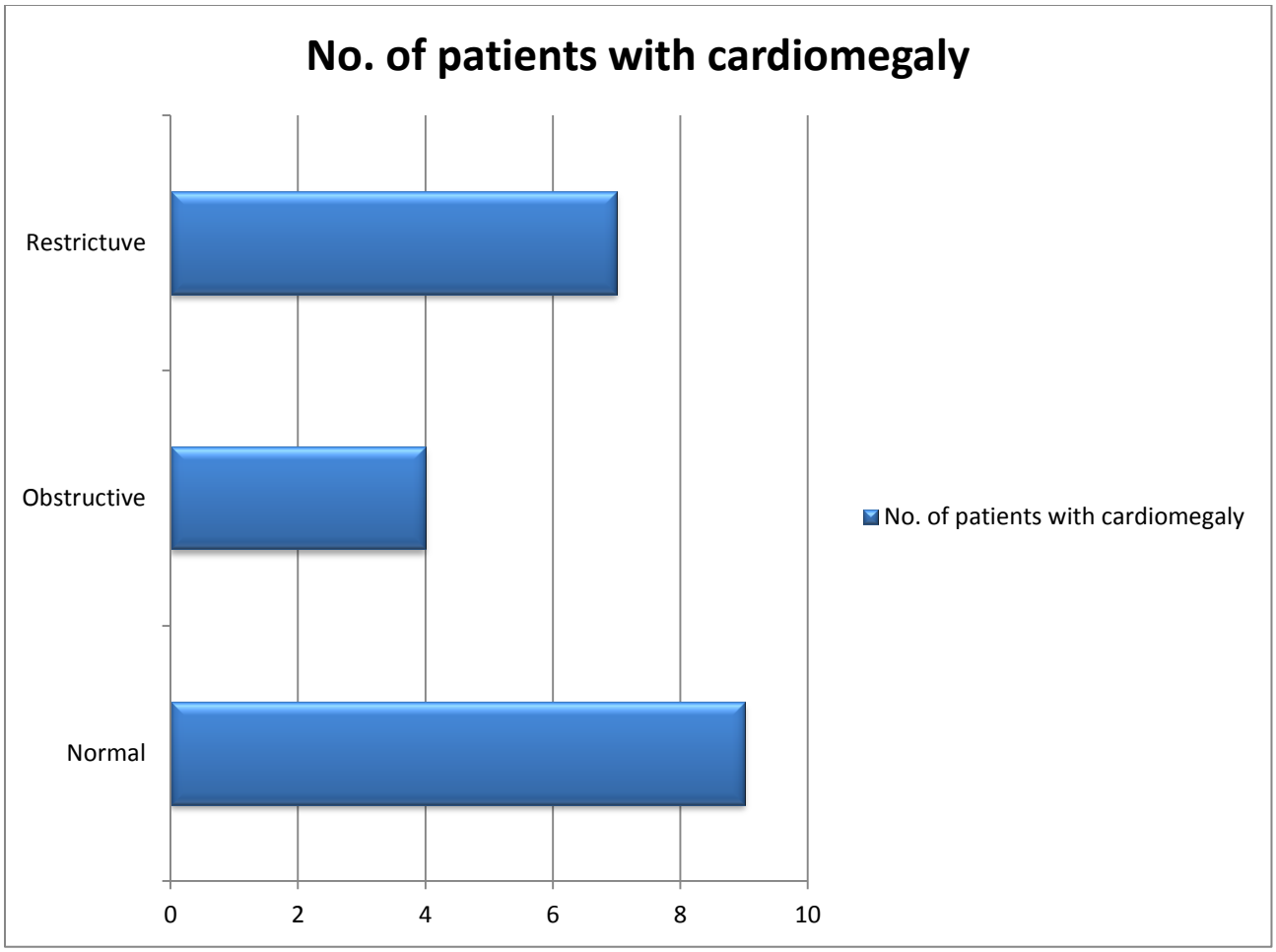
	MALE	FEMALE	TOTAL
NORMAL	8	3	11
OBSTRUCTIVE	2	1	3
RESTRICTIVE	11	4	15
TOTAL	21	8	29

Among the study population 29 patients were having rheumatic heart disease. 21 were males and 8 were females. Among the 21 males, 8 showed normal PFT pattern,3 showed obstructive pattern and 11 were found to have restrictive pattern. Among the females , 3 were found to have normal pattern, obstructive pattern in 1 patient and restrictive pattern seen in 4 patients .


No. of hypertensive patients
Restrictive
Obstructive
Normal
0
5
10
15
20
25
30
No. of hypertensive patients

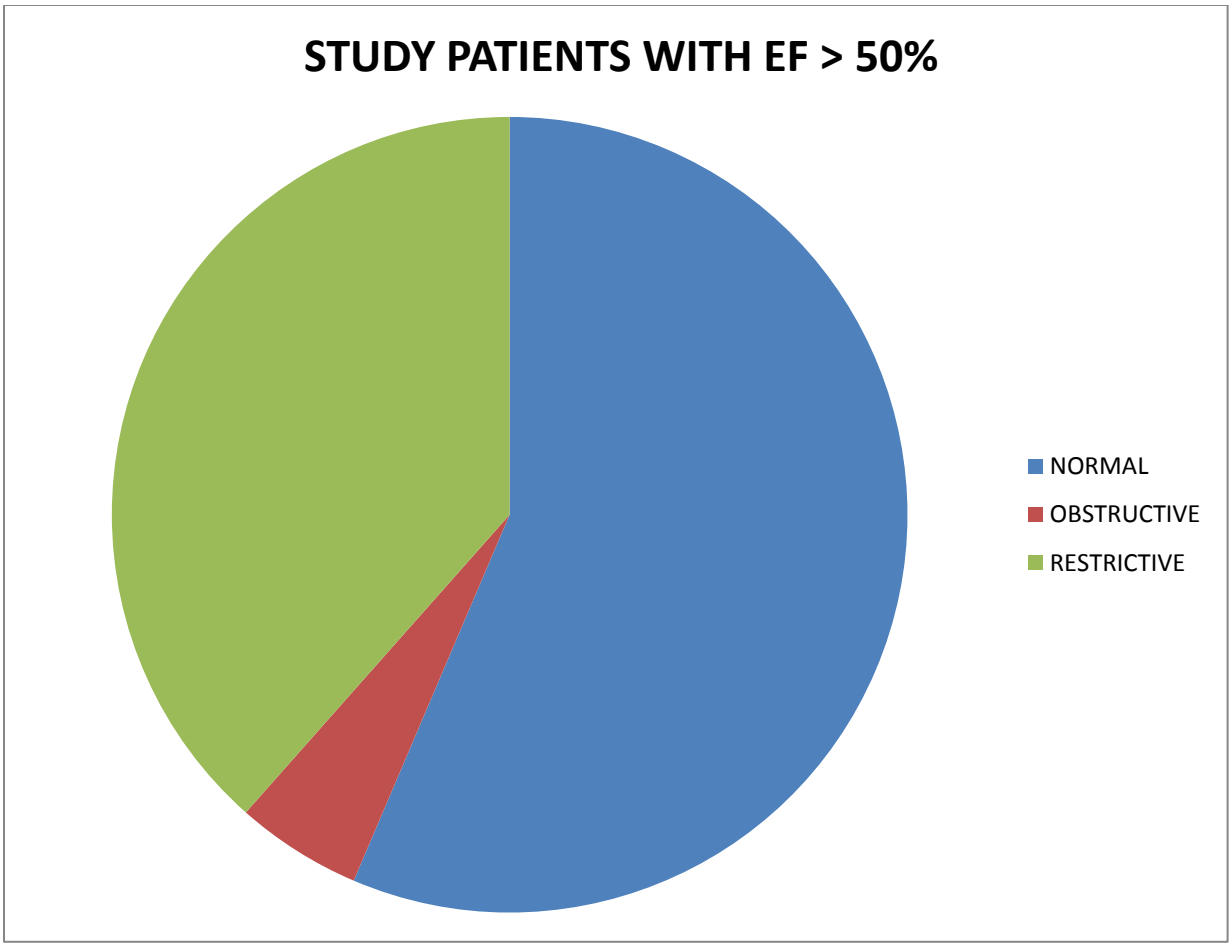
	MALE	FEMALE	TOTAL
NORMAL	17	11	28
OBSTRUCTIVE	4	1	5
RESTRICTIVE	8	5	13
TOTAL	29	17	46

Among the study population, 46 were found to be hypertensive. Among them, 29 were males and 17 were females. Among 29 males, 17 were found to have normal PFT pattern, 4 were having obstructive pattern and 8 were having restrictive pattern. Out of 17 females 11 were having normal PFT pattern, 5 were having obstructive pattern and 13 showed restrictive pattern.


No. of patients with cardiomegaly
Restrictuve
Obstructive
Normal
0
2
4
6
8
10
No. of patients with cardiomegaly

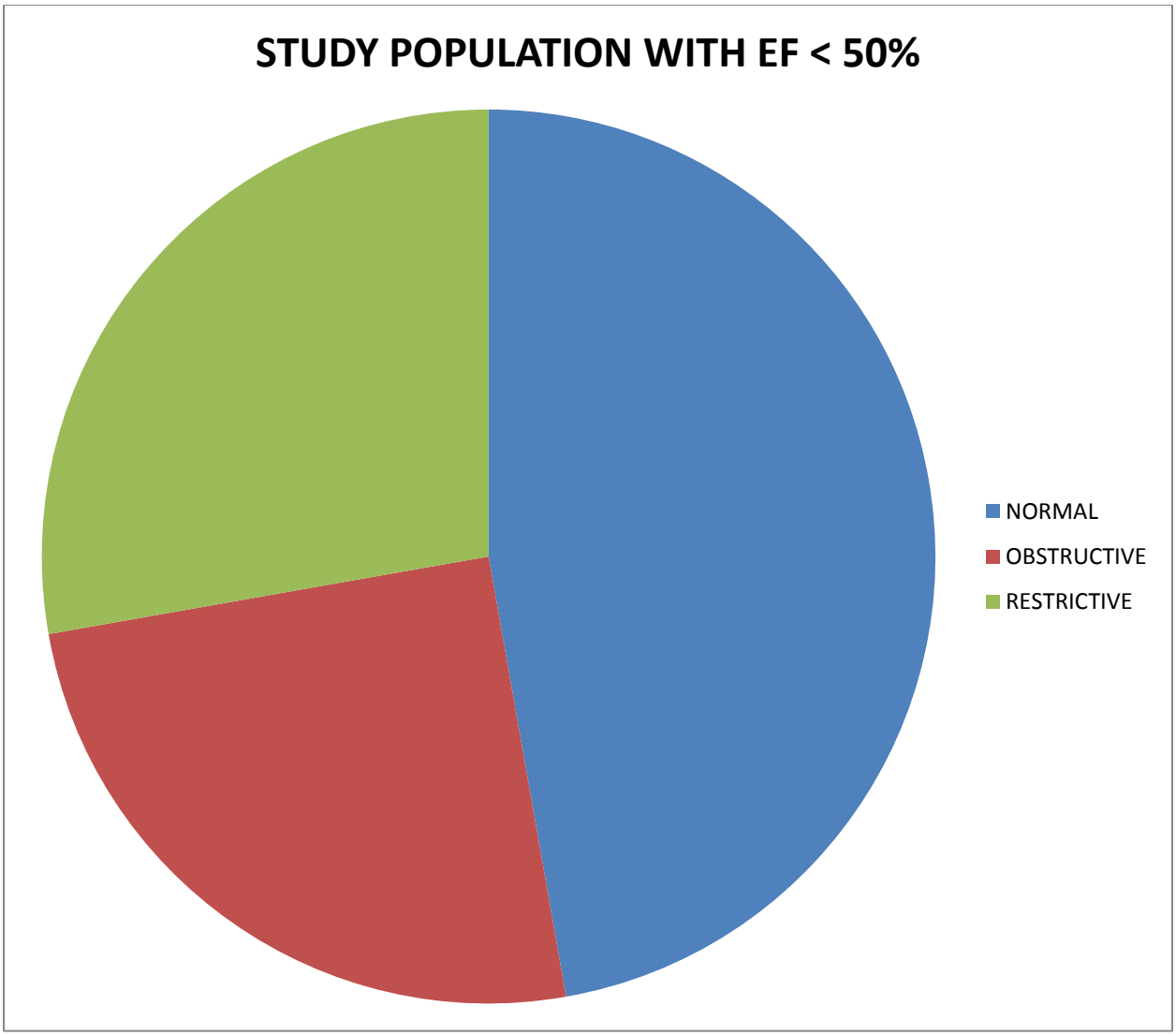
	MALE	FEMALE	TOTAL
NORMAL	5	4	9
OBSTRUCTIVE	2	2	4
RESTRICTIVE	3	4	7
TOTAL	10	10	20

Among the study population , 20 were diagnosed to have cardiomegaly on chest radiography. Among the 10 males, 5 were having normal PFT values, 2 showed obstructive pattern and 3 showed restrictive pattern.among females, 9 were found to have normal PFT study, 4 patients were having obstructive pattern and 7 showed restrictive pattern.


STUDY PATIENTS WITH EF > 50%
NORMAL
OBSTRUCTIVE
RESTRICTIVE

	MALE	FEMALE	TOTAL
NORMAL	16	6	22
OBSTRUCTIVE	1	1	2
RESTRICTIVE	9	6	15
TOTAL	26	13	39

Among the study sample, 39 patients were having ejection fraction more than 50%. Among them 26 were male patients and 13 were female patients. Among the 26 males, 16 showed normal PFT payyerns,1 showed obstructive pattern and 9 were showing restrictive pattern. Among females,normal pattern was seen in 6 patients, obstructive pattern in 1 and restrictive pattern in 6 patients.


STUDY POPULATION WITH EF < 50%
NORMAL
OBSTRUCTIVE
RESTRICTIVE

	MALE	FEMALE	TOTAL
NORMAL	10	7	17
OBSTRUCTIVE	6	3	9
RESTRICTIVE	7	3	10
TOTAL	23	13	36

Among the study population 36 patients were having ejection fraction less than50%. Out of these 36 patients,23 were males and 13 were females. Among the 23 males 10 were having normal PFT patterns, 6 showed obstructive pattern and 7 showed restrictive pattern. Out of 13 females, 7 were having normal PFT pattern, obstructive pattern seen in3 patients and restrictive pattern in 3 patients.

DISCUSSION

Heart failure is one of the common causes of mortality and morbidity of Indian population. However the pulmonary function of such patients has not been studied adequately. This study, “STUDY OF PULMONARY FUNCTION TESTS IN CARDIAC PATIENTS “is a observational study done on 75 patients with cardiac failure admitted in Tirunelveli medical college hospital, after they were revived from cardiac failure.

A study population included 49 male patients and 26 female patients. Of the male patients 29 were diagnosed to be having coronary artery heart disease and 20 patients were diagnosed to be having Rheumatic Heart Disease. Among the 26 female patients 17 were found to be having coronary artery heart disease and 9 were found to be having Rheumatic Heart Disease.

In this study pulmonary function test was done on these patients once they revived from cardiac failure. The parameters studied were forced expiratory volume in first second (FEV1), forced vital capacity (FVC), and ratio of FEV1/FVC. From these parameters whether these patients were having obstructive or restrictive pattern of respiratory involvement was studied. Supportive investigations such as chest x-ray PA view, ECG and Echocardiogram was done.

Among the studied patients 52% had normal pattern of pulmonary function test, 32% had restrictive pattern and 16% had obstructive pattern. Out of the male patients 53.06% had normal pattern, 30.61% had restrictive pattern and 16.32% had obstructive pattern. Out of the female patients studied, 50% had normal pattern, 34.61% had restrictive pattern and 15.38% had obstructive pattern. This shows that both males and females in the study population had similar type of distribution of the pulmonary function test pattern.

61.33% (46) of the studied population had coronary artery disease as the cause of heart failure. In them 60.86% of patients had normal pattern of PFT, 17.39% had obstructive pattern and 21.73% had restrictive pattern. 38.66% (29) of the studied patients had rheumatic heart disease as the cause of heart failure. Among them 37.93% had normal pulmonary function test pattern, while 10.34% had obstructive pattern and 51.72% had restrictive pattern. From this it is clear that compared to cardiac failure patients with coronary artery disease, patients with rheumatic heart disease had lower proportion of patients with normal pulmonary function test pattern. The prevalence of restrictive pattern of pulmonary function test was more in those with rheumatic heart disease (51.72%) than those with coronary artery disease (38.66%).

Among the study population 46 patients (61.33) were found to be hypertensive. In them, 60.86% had normal pattern of pulmonary function test. 10.86% had obstructive pattern while 28.26% had restrictive pattern.

Out of the studied patients 20 (26.66%) had cardiomegaly on chest xray. Among them 45% had normal pattern of PFT while 20% had obstructive pattern and 35% had restrictive pattern.

39 patients (52%) had ejection fraction of more than 50%,. Among them, 56.41% had normal pulmonary function tests. 5.12% had obstructive pattern and 38.46% had restrictive pattern. 36 patients (48%) had ejection fraction less than 50%. Among them, 47.22% had normal pattern of pulmonary function test while 25% had obstructive pattern and 27.77% had restrictive pattern. The prevalence of obstructive pattern was more in patients with left ventricular ejection fraction of less than 50%.

CONCLUSION

The presence of impaired pulmonary function tests in cardiac failure patients has been already demonstrated in various studies. This may be due to various reasons like pulmonary congestion, pulmonary hypertension, respiratory muscle wasting due to cardiac cachexia and co-existent respiratory diseases in patients with cardiac failure. More than half of the cardiac failure patients had normal pulmonary function pattern. In those who had abnormal pulmonary function pattern, the incidence of restrictive pattern was more than that of obstructive pattern. The prevalence of restrictive pattern of pulmonary function test was more in patients with rheumatic heart disease when compared to patients with coronary artery disease patients for unknown reason. As the LV ejection fraction of the patients with cardiac failure decreased there is a higher incidence of obstructive pattern of pulmonary function test.

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ANNEXURE 1

COMMON RESPIRATORY DISEASES BY DIAGNOSTIC METHODS

Obstructive
- Asthma
- Chronic obstructive lung disease (chronic bronchitis, emphysema)
- Bronchiectasis
- Cystic fibrosis
- Bronchiolitis

Restrictive—Parenchymal
- Sarcoidosis
- Idiopathic pulmonary fibrosis
- Pneumoconiosis
- Drug- or radiation-induced interstitial lung disease

Restrictive—Extraparenchymal
- Neuromuscular
  - Diaphragmatic weakness/paralysis
  - Myasthenia gravis
  - Guillain-Barré syndrome
  - Muscular dystrophies
  - Cervical spine injury
- Chest wall
  - Kyphoscoliosis
  - Obesity
  - Ankylosing spondylitis

ANNEXURE 2

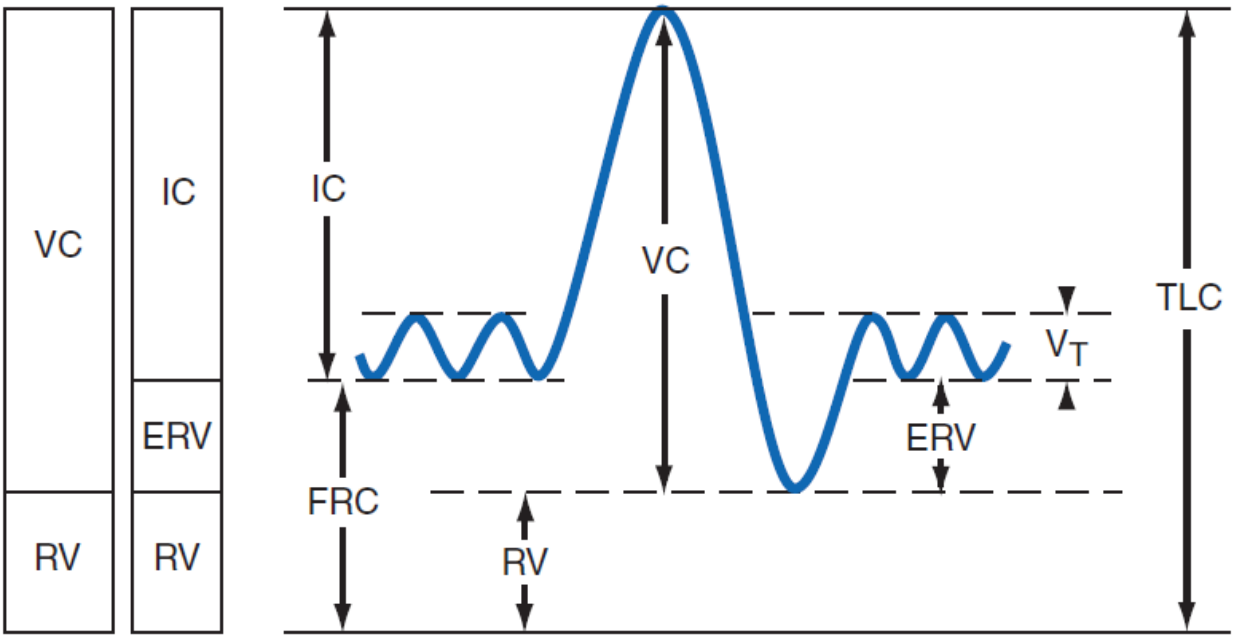
ALTERATIONS IN VENTILATOR FUNCTIONS

	TLC	RV	VC	FEV_1/VC	MIP
Obstructive	N to ↑	↑	↓ or N	↓	N
Restrictive					
Pulmonary parenchymal	↓	↓	↓	N to ↑	N
Extraparenchymal					
Neuromuscular weakness	↓	Variable[a]	↓	Variable[a]	↓
Chest wall deformity	↓	Variable[b]	↓	N	N

[a]Depends upon expiratory muscle strength.
[b]Depends upon specific chest wall disorder.

ANNEXURE 3

LUNG VOLUMES BY A SPIROGRAPHIC TRACING



ANNEXURE 4

NEWYORK HEART ASSOSIATION CLASSIFICATION

Functional Capacity	Objective Assessment
Class I	Patients with cardiac disease but without resulting limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitations, dyspnea, or anginal pain.
Class II	Patients with cardiac disease resulting in slight limitation of physical activity. They are comfortable at rest. Ordinary physical activity results in fatigue, palpitation, dyspnea, or anginal pain.
Class III	Patients with cardiac disease resulting in marked limitation of physical activity. They are comfortable at rest. Less than ordinary activity causes fatigue, palpitation, dyspnea, or anginal pain.
Class IV	Patients with cardiac disease resulting in inability to carry on any physical activity without discomfort. Symptoms of heart failure or the anginal syndrome may be present even at rest. If any physical activity is undertaken, discomfort is increased.

Source: Adapted from New York Heart Association, Inc., *Diseases of the Heart and Blood Vessels: Nomenclature and Criteria for Diagnosis*, 6th ed. Boston, Little Brown, 1964, p. 114.

ANNEXURE 5

ETIOLOGIES OF HEART FAILURE

ANNEXURE 6 – MASTER CHART

Depressed Ejection Fraction (<40%)

- Coronary artery disease
  - Myocardial infarction[a]
  - Myocardial ischemia[a]
- Chronic pressure overload
  - Hypertension[a]
  - Obstructive valvular disease[a]
- Chronic volume overload
  - Regurgitant valvular disease
  - Intracardiac (left-to-right) shunting
  - Extracardiac shunting
- Nonischemic dilated cardiomyopathy
  - Familial/genetic disorders
  - Infiltrative disorders[a]
  - Toxic/drug-induced damage
  - Metabolic disorder[a]
  - Viral
  - Chagas' disease
- Disorders of rate and rhythm
  - Chronic bradyarrhythmias
  - Chronic tachyarrhythmias

Preserved Ejection Fraction (>40–50%)

- Pathological hypertrophy
  - Primary (hypertrophic cardiomyopathies)
  - Secondary (hypertension)
- Aging
- Restrictive cardiomyopathy
  - Infiltrative disorders (amyloidosis, sarcoidosis)
  - Storage diseases (hemochromatosis)
- Fibrosis
- Endomyocardial disorders

Pulmonary Heart Disease

- Cor pulmonale
- Pulmonary vascular disorders

High-Output States

- Metabolic disorders
  - Thyrotoxicosis
  - Nutritional disorders (beriberi)
- Excessive blood-flow requirements
  - Systemic arteriovenous shunting
  - Chronic anemia

Pulmonary Function Tests in Cardiac Patients

S.No.	Name	Age/Sex	IP No.	Hb%	RFT	↑BP	ECG	Diagnosis	X Ray Chest	ECHO	PFT (%Predicted)		
											FEV_1	FVC	FEV_1/FVC
1	Thenammal	58/F	47769	12.2	18	Yes					92	64	56
					0.9		Lateral Wall Ischemia	CAHD	Within Normal Limits	EF-56%	Obstructive		
2	Mariappan	37/M	47735	18.2	18	Yes					82	93	90
					0.8		RBBB	RHD-MR	Cardiomegaly	EF-53%	Restrictive		
3	Indrani	37/F	46783	9.3	16	Yes					81	84	82
					0.7		Old AWMI	CAHD	Within Normal Limits	EF-58%	Normal		
4	Sita	47/F	47738	12.1	39	Yes					83	90	91
					1.1		Anterior Wall MI	CAHD	Within Normal Limits	EF-48%	Normal		
5	Venkatachalam	56/M	14658	11.7	88	Yes					82	86	83
					1.6		Unstable Angina	CAHD	Minimal Pleural Effusion	EF-51%	Normal		
6	Prema	19/F	47962	11.8	19.6	No			Straightening Of Left		49	58	66
					1.1		Within Normal Limits	RHD-MS	Heart Border	EF-49%	Obstructive		
7	Madathiammal	55/F	47992	12.3	29	No					41	39	62
					0.7		Anterior Wall Ischemia	CAHD	Cardiomegaly	EF-47%	Obstructive		
8	Vellammal	42/F	47407	13.1	21	Yes					83	81	79
					0.7		Lateral Wall Ischemia	CAHD	Within Normal Limits	EF-40%	Normal		
9	Arunachalam	34/M	46227	10	17.6	Yes					83	87	81
					1.1		Anterior Wall MI	CAHD	Within Normal Limits	EF-59%	Normal		
10	Devaraj	59/M	46336	12	31.8	No					81	88	84
					0.8		Old AWMI	CAHD	Within Normal Limits	EF-51%	Normal		
11	Krishnamoorthy	50/M	46262	10	36	Yes					70	67	79
					1.2		Anterior Wall Ischemia	RHD-AS	Within Normal Limits	EF-42%	Restrictive		
12	Muthuraj	55/M	41828	13.1	26	Yes					45	54	61
					1.3		Inferolateal Ischemia	CAHD	Within Normal Limits	EF-45%	Obstructive		
13	Thangavel	56/M	38829	11	52	Yes					87	81	79
					1.1		Complete RBBB	CAHD	Within Normal Limits	EF-55%	Normal		
14	Pandi	50/M	38967	13.4	39	No					71	65	73
					1		Old AWMI	CAHD	Within Normal Limits	EF-52%	Restrictive		
15	Maharaja	18/M	38806	9.7	16	No					73	61	77
					1.9		RVH	RHD-MS	Within Normal Limits	EF-57%	Restrictive		
16	Muthu	55/M	37431	14	34	Yes					83	88	81

Pulmonary Function Tests in Cardiac Patients

					1.1		Inferior Wall Ischemia	RHD-AS	Within Normal Limits	EF-39%	Normal		
17	Perumal	45/M	37458	11	27	Yes					91	89	94
					1.2		Unstable Angina	CAHD	Within Normal Limits	EF-55%	Normal		
18	Ramaiah	58/M	37506	13.1	22	Yes					51	46	62
					1.4		Sinus Tachycardia	RHD-AS	Within Normal Limits	EF-42%	Obstructive		
19	Subbaiah	57/M	25116	15	16.9	Yes					113	93	120
					0.9		Inferolateal Ischemia	CAHD	Within Normal Limits	EF-52%	Normal		
20	Nayagam	55/M	24814	13.5	18	Yes					55	76	70
					0.7		Old IWMI	CAHD	Within Normal Limits	EF-44%	Obstructive		
21	Muppidathy	50/F	15104	10.4	18	Yes					29	36	80
					0.9		Incomplete RBBB	CAHD	Cardiomegaly	EF-55%	Restrictive		
22	Nambiammal	38/F	16750	10	34	No			Straightening Of Left		63	76	83
					0.8		Within Normal Limits	RHD-MS	Heart Border	EF-51%	Restrictive		
23	Rajagopal	50/M	14670	10	34	Yes					87	85	81
					1.6		RBBB	CAHD	Within Normal Limits	EF-57%	Normal		
24	Muthuselvi	55/F	14186	13.5	16	Yes					69	60	113
					1.7		Lateral Wall Ischemia	CAHD	Within Normal Limits	EF-51%	Restrictive		
25	Muthukutty	49/F	15111	9.2	38	Yes					88	77	103
					1.4		Anterior Wall Ischemia	RHD-AS	Cardiomegaly	EF-46%	Normal		
26	Velayudham	52/M	14630	10.3	28	Yes					107	80	73
					0.9		Lateral Wall Ischemia	CAHD	Within Normal Limits	EF-56%	Normal		
27	Palaniammal	21/F	14514	9.5	31	No					78	75	92
					1.2		RBBB	RHD-MR	Cardiomegaly	EF-55%	Restrictive		
28	Shahul Hameed	48/M	15851	14.2	16	Yes					63	76	83
					1		Inferolateal Ischemia	CAHD	Within Normal Limits	EF-51%	Restrictive		
29	Alagar	47/M	15914	7.5	21	No					74	61	92
					1.1		Anterior Wall Ischemia	RHD-AS	Within Normal Limits	EF-39%	Restrictive		
30	Shanmugaiah	53/M	16132	10.6	23	No					90	82	86
					1		LVH	CAHD	b/l Pleural Effusion	EF-42%	Normal		
31	Ganapathy	48/M	15807	14.1	29	Yes					70	60	115
					1.2		Old IWMI/AWMI	CAHD	Cardiomegaly	EF-53%	Restrictive		
32	Murugan	50/M	16222	14.2	38	Yes			Minimal Right Pleural		57	53	106
					1.7		Sinus Tachycardia	RHD-MR	Effusion	EF-55%	Restrictive		

Pulmonary Function Tests in Cardiac Patients

33	Anbalagan	45/M	18876	13	55	Yes					30	40	75
					1		LBBB Old ASMI	CAHD	Within Normal Limits	EF-51%	Restrictive		
34	Dharmaraj	47/M	20190	15	28	No					26	42	61
					0.8		Anterior Wall Ischemia	CAHD	Atheromatous Aorta	EF-44%	Obstructive		
35	Chelladurai	51/M	20169	15.3	19	Yes					111	119	91
					0.8		LBBB	RHD-AR	Cardiomegaly	EF-55%	Normal		
36	Tamilselvan	30/M	44844	13.2	21	No			Straightening of Left		91	96	95
					1.3		P mitrale RVH	RHD-MS	Heart Border	EF-59%	Normal		
37	Mohana Kumar	38/M	41755	14.2	27.1	No					60	68	87
					1.4		LVH	RHD-AS	Within Normal Limits	EF-39%	Restrictive		
38	Helen	45/F	42388	13.7	26	No					91	99	89
					1.1		Anterior Wall Ischemia	RHD-AS	Cardiomegaly	EF-42%	Normal		
39	Esakki Muthu	44/M	46679	10.3	24	Yes					84	92	83
					1.3		Inferolateal Ischemia	CAHD	Within Normal Limits	EF-52%	Normal		
40	Packiyanathan	58/M	24661	9.00	33	No					89	99	79
					1.4		Anterior Wall Ischemia	RHD-AS	Within Normal Limits	EF-39%	Normal		
41	Muthukumar	59/M	37881	8.7	26	No					61	52	79
					0.8		Inferolateal Ischemia	RHD-AS	Within Normal Limits	EF-37%	Restrictive		
42	Ramalakshmi	49/F	21561	10	34	Yes					113	109	93
					1.2		Old AWMI	CAHD	Within Normal Limits	EF-52%	Normal		
43	Petchiammal	54/F	54221	9	41	Yes					83	87	91
					1		LVH	CAHD	Cardiomegaly	EF-47%	Normal		
44	Jeyapal	57M	21032	9.3	32	No					81	93	86
					1.6		LBBB	RHD-MR	Cardiomegaly	EF-52%	Normal		
45	Devadayavu	41/M	54321	11	30	No			Straightening Of Left		61	52	79
					1		P mitrale RVH	RHD-MS	Heart Border	EF-43%	Restrictive		
46	Jamaal	57/M	49443	12	28	Yes					81	89	93
					0.8		Inferior Wall Ischemia	RHD-AS	Within Normal Limits	EF-35%	Normal		
47	Michael	48/M	39621	13	20	Yes					89	96	99
					1		Anterior Wall Ischemia	CAHD	Cardiomegaly	EF-39%	Normal		
48	Tulasi	39/F	45678	12	27	No					103	109	96
					1.6		Atrial Fibrillation	RHD-MS	Atheromatous Aorta	EF-49%	Normal		
49	Beula	37/F	29311	8.2	29	Yes					81	88	79

Pulmonary Function Tests in Cardiac Patients

					0.7		LVH	CAHD	Cardiomegaly	EF-51%	Normal		
50	Esakki Pandi	43/M	28334	10.4	22	No					81	93	83
					1.1		Sinus Tachycardia	RHD-MR	Cardiomegaly	EF-41%	Normal		
51	Dinesh	44/M	31003	12.3	32	Yes					93	101	90
					2		Unstable Angina	CAHD	Within Normal Limits	EF-44%	Normal		
52	Kovil Raj	49/M	45551	11.2	25	No					49	55	63
					1.1		Old AWMI	CAHD	Within Normal Limits	EF-55%	Obstructive		
53	Poornammal	51/F	37761	14.2	41	Yes					55	53	83
					0.6		LBBB	RHD-AS-AR	Atheromatous Aorta	EF-37%	Restrictive		
54	Vijila	54/F	39031	13	32	Yes					83	88	79
					1.3		Old AWMI	CAHD	Within Normal Limits	EF-43%	Normal		
55	Kala	55/F	44091	12	26	Yes					33	45	74
					0.8		Inferolateal Ischemia	CAHD	Within Normal Limits	EF-59%	Restrictive		
56	Thangammal	47/F	32113	11	39	Yes					91	95	87
					1.3		Anterior Wall Ischemia	CAHD	b/l Pleural Effusion	EF-51%	Normal		
57	Muthupandi	33/M	37220	11.7	34	No					59	51	67
					1.8		Sinus Tachycardia	RHD-MS	Within Normal Limits	EF-41%	Obstructive		
58	Vinothan	39/M	44617	13	32	Yes					87	81	72
					1		Anterior Wall MI	CAHD	Within Normal Limits	EF-54%	Normal		
59	Narayanan	56/M	32554	16	29	No					29	38	82
					1.8		Inferolateal Ischemia	RHD-AS	Within Normal Limits	EF-33%	Restrictive		
60	Mohammad	47/M	44421	14	38	Yes					87	97	89
					1.2		LVH	CAHD	Cardiomegaly	EF-55%	Normal		
61	Veerabahu	59/M	33312	12.6	31	Yes					44	58	78
					1.4		Old AWMI	CAHD	Within Normal Limits	EF-55%	Restrictive		
62	Murugavel	26/M	54546	16	24	No			Straightening Of Left		98	102	79
					0.8		Atrial Fibrillation	RHD-MS	Heart Border	EF-43%	Normal		
63	Ramanathan	51/M	41320	14	44	Yes					99	113	87
					1.1		Anterior Wall Ischemia	CAHD	Within Normal Limits	EF-49%	Normal		
64	Rajam	49/F	20133	12	39	Yes					82	89	76
					1.4		Inferolateal Ischemia	CAHD	Within Normal Limits	EF-55%	Normal		
65	Kanmani	29/F	31556	10	31	No					41	58	81
					1		RVH	RHD-MS	Cardiomegaly	EF-56%	Restrictive		

66	Kaveri	58/F	42901	13	24	Yes					83	88	93
					1.7		Unstable Angina	CAHD	Within Normal Limits	EF-43%	Normal		
67	Petchi Devar	59/M	25820	17	35	No					99	108	87
					1.2		Old AWMI	CAHD	Within Normal Limits	EF-56%	Normal		
68	Thennayya	54/M	30271	12	32	No					89	92	93
					0.8		Anterior Wall Ischemia	CAHD	Within Normal Limits	EF-50%	Normal		
69	Muthaiah	39/M	12445	13	40	No					49	42	79
					1.3		RBBB	RHD-MR	Cardiomegaly	EF-56%	Restrictive		
70	Vinayagam	56/M	14450	10.5	35	Yes					56	47	61
					1.2		LVH	CAHD	Cardiomegaly	EF-43%	Obstructive		
71	muthukumar	45/M	12235	11.6	22	Yes					99	101	88
					1.2		Anterior wall ischemia	CAHD	cardiomegaly	EF-35%	normal		
72	issakiammal	55/F	13345	8.9	31	yes					58	49	83
					2.1		LVH	CAHD	within normal limits	EF-40%	restrictive		
73	sivakami	35/F	18897	11.1	23	no					49	67	99
					1.2		RBBB	CAHD	cardiomegaly	EF 45%		restrictive	
74	padamalayan	56/M	77383	13.1	22	yes					67	58	92
					1.2		sinus tachycardia	RHD MS	aightening of left heart bor	EF 36%	restrictive		
75	lakshmi	46/F	56744	12.1	33	no					47	56	67
					1.6		LVH	CAHD	cardiomegaly	EF 45%	obstructive		

ANNEXURE 7

Tirunelveli Government Medical College Hospital

Department of Medicine

Study of Pulmonary Function tests in Cardiac patients

Proforma

Sl no: IP no:

Name: Age: Sex: Occupation:

Address:

Complaints:

1. Chest pain-
2. Breathlessness-
3. Palpitations-
4. Sweating-
5. Swelling of both legs-

Past history:

Diabetic Hypertension Respiratory disease

Personal history:

Alcoholic Smoking Tobacco chewing

General Examination

Anaemia	Clubbing	Cyanosis	Pedal edema	Jaundice
PR	RR	BP	JVP	

Systemic examination

CVS

RS

GIT

CNS

Diagnosis .....

Investigations

CBC

RBS

RFT

ECG-all leads

Chest Xray PA view

Pulmonary function tests

Indices	Value	Predicted	% predicted
FEV1			
FVC			
PEF			
FEV1/FVC			
MEF (25-75)			