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IN

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‘‘A STUDY ON RELATIONSHIP BETWEEN SEVERITY OF LIVER CIRRHOSIS AND PULMONARY FUNCTION TESTS’’

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Dr. NIVEDITHA.R

ABBREVIATIONS

ABG	-	Arterial Blood Gas
ALT	-	Alanine Aminotransferase
ANOVA	-	Analysis of Variance
AST	-	Aspartate Aminotransferase
CO2	-	Carbon Dioxide
COPD	-	Chronic Obstructive Pulmonary Disease
FEF 25-75%	-	Forced Expiratory Flow at 25-75% of Forced Vital Capacity
FEV1	-	Forced Expiratory Volume in 1 second
FVC	-	Forced Vital Capacity
HCO3	-	Bicarbonate
HE	-	Hepatic Encephalopathy
HPS	-	Hepatopulmonary Syndrome
INR	-	International Normalized Ratio
MELD	-	Model for End-stage Liver Disease
mmHg	-	Millimeters of Mercury
O2	-	Oxygen
PCO2	-	Partial Pressure of Carbon Dioxide
PFT	-	Pulmonary Function Test
POPH	-	Portopulmonary Hypertension
PO2	-	Partial Pressure of Oxygen
PT	-	Prothrombin Time
SD	-	Standard Deviation
SO2	-	Oxygen Saturation
SpO2	-	Peripheral Oxygen Saturation
USG	-	Ultrasonography

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Introduction:

“Liver cirrhosis represents the final common pathway for chronic liver diseases, characterized by fibrosis, architectural distortion, and hepatic dysfunction.” While hepatic manifestations are well-documented, cirrhosis affects multiple organ systems, including the lungs[1]. Pulmonary complications in cirrhosis include hepatopulmonary syndrome, portopulmonary hypertension, hepatic hydrothorax, and altered pulmonary function, significantly impacting morbidity and mortality. “This study aimed to evaluate the relationship between liver cirrhosis severity and pulmonary function parameters to establish patterns that might guide clinical management and prognostication.”

Methods:

“Sixty-five patients with liver cirrhosis were categorized according to Child-Pugh classification: Child A (n=6), Child B (n=21), and Child C (n=38).” Demographic characteristics, clinical features, Child-Pugh and MELD scores, ultrasonographic findings, arterial blood gases, and pulmonary function tests were assessed. Pulmonary function parameters included FVC, FEV1, FEV1/FVC ratio, and FEF 25-75%, measured both pre- and post-bronchodilator administration. Statistical analysis included ANOVA, chi-square test, and correlation analysis.

Results:

Significant differences were observed in age across Child-Pugh groups ($p=0.019$). Child-Pugh and MELD scores showed expected significant differences ($p<0.001$). Ascites severity increased significantly with worsening liver function ($p<0.001$). Pulmonary function tests revealed significant declines in FVC and FEV1 percentages with increasing disease severity ($p<0.05$), both pre- and post-

bronchodilator. Restrictive ventilatory pattern predominated in Child C patients (94.7%) compared to Child A (33.3%) and Child B (47.6%) ($p<0.001$). Arterial blood gases showed a trend toward decreasing pH and PO2 with worsening liver function. Significant negative correlations were found between Child-Pugh score and pulmonary function parameters including FVC, FEV1, and FEF 25-75% ($p<0.001$), while correlations with MELD score were weaker but still significant for FVC and FEV1.

Conclusion:

Pulmonary function deteriorates progressively with increasing severity of liver cirrhosis, predominantly manifesting as a restrictive pattern in advanced disease. The significant negative correlations between liver disease severity scores and pulmonary function parameters suggest that pulmonary impairment parallels hepatic dysfunction. These findings highlight the importance of routine pulmonary function assessment in cirrhotic patients, particularly those with advanced disease, to identify abnormalities early and implement appropriate interventions.

Keywords:

Liver cirrhosis, Child-Pugh classification, MELD score, Pulmonary function tests, Obstructive ventilatory pattern, Arterial blood gases, Hepatopulmonary syndrome, Ascites, FEV1, FVC

INTRODUCTION

Liver cirrhosis represents a significant global health burden, characterized by progressive fibrosis and distortion of hepatic architecture that leads to portal hypertension and various systemic complications. While the hepatic manifestations of cirrhosis are well-documented, the disease's impact on other organ systems, particularly the pulmonary system, has gained increasing attention in recent years.[1] The complex relationship between hepatic dysfunction and pulmonary abnormalities presents a critical area of investigation, as respiratory complications significantly influence the morbidity and mortality of cirrhotic patients.

The concept of hepatopulmonary syndrome (HPS) and portopulmonary hypertension (PPH) has been well established, demonstrating the direct impact of liver disease on pulmonary function. However, recent evidence suggests that pulmonary dysfunction in cirrhosis extends beyond these classical syndromes, with alterations in respiratory mechanics and gas exchange occurring even in the absence of clinically evident pulmonary disease.[2] Understanding these subtle changes through pulmonary function testing may provide valuable insights into disease progression and patient outcomes.

The pathophysiological mechanisms underlying pulmonary dysfunction in liver cirrhosis are complex and multifaceted. Portal hypertension leads to the development of portosystemic collaterals and the release of vasoactive substances, which can affect pulmonary vasculature and ventilation-perfusion matching.[3] Additionally, the presence of ascites can mechanically impair diaphragmatic function and reduce lung volumes, while muscle wasting associated with advanced liver disease may affect respiratory muscle strength and endurance.

Pulmonary function tests (PFTs) serve as objective measures to assess various aspects of respiratory function, including ventilatory capacity, lung volumes, and gas exchange efficiency. These tests can detect subtle abnormalities in respiratory function before clinical manifestations become apparent.[4] The systematic evaluation of PFTs in cirrhotic patients may reveal patterns of dysfunction that correlate with disease severity and could potentially serve as prognostic indicators.

Recent studies have suggested that alterations in pulmonary function may parallel the progression of liver disease, with more severe hepatic dysfunction associated with greater impairment in respiratory parameters.[5] "The Child-Pugh classification and Model for End-Stage Liver Disease (MELD) score, widely used to assess liver disease severity, may show correlations with specific patterns of pulmonary dysfunction." Understanding these relationships could enhance our ability to predict and manage respiratory complications in cirrhotic patients.

The impact of cirrhosis on specific pulmonary function parameters has shown varying patterns across different studies. Some research has demonstrated predominant restrictive defects, particularly in patients with significant ascites, while others have reported obstructive patterns or mixed ventilatory abnormalities.[6] The diffusing capacity for carbon monoxide (DLCO) has been consistently shown to be affected, suggesting impaired gas exchange as a common feature of advanced liver disease.[7]

The clinical implications of understanding the relationship between liver cirrhosis severity and pulmonary function extend beyond diagnostic considerations. This knowledge could influence therapeutic strategies, such as the timing of therapeutic paracentesis, the use of bronchodilators, or the implementation of pulmonary rehabilitation programs. Moreover, pre-operative assessment of pulmonary

function may be particularly relevant for patients being evaluated for liver transplantation.[8]

The evolution of pulmonary dysfunction throughout the natural history of liver cirrhosis remains incompletely understood. While some abnormalities may be reversible with improvement in liver function or successful transplantation, others may persist or progress despite hepatic improvement.[9] Longitudinal assessment of pulmonary function in relation to liver disease severity could provide valuable insights into the temporal relationship between hepatic and pulmonary dysfunction.

The interaction between liver cirrhosis and pulmonary function is further complicated by common comorbidities such as smoking, underlying lung disease, and cardiovascular conditions. These factors may confound the interpretation of PFT results and need to be carefully considered when evaluating the direct impact of liver disease on respiratory function.[10] Additionally, the presence of ascites, pleural effusions, and other complications of portal hypertension may mechanically affect pulmonary function measurements.

This research aims to systematically evaluate the relationship between liver cirrhosis severity and pulmonary function test parameters, with the goal of identifying patterns that could enhance our understanding of hepatopulmonary interactions and improve patient care. By correlating PFT findings with established measures of liver disease severity, we hope to contribute to the development of more comprehensive approaches to monitoring and managing patients with advanced liver disease.

AIM & OBJECTIVES

Objectives:

1. To correlate the severity of Liver cirrhosis and pulmonary function tests.

REVIEW OF LITERATURE

"REVIEW OF PULMNORY FUNCTION TESTS"

"The exchange of gases between the blood and the ambient air is the lung's primary job. This suggests that the only necessary test for pulmonary function may be the measurement of the tension of gases in the blood leaving the lung. Nevertheless, despite the existence of severe lung illness, the "pulmonary reserve" is so great and the mechanism that these gas tensions may stay within the normal range."

Because of these factors, measurements of the lung's size (or volume), expansibility (elasticity), ventilatory ability (forced expiratory volume), or gas transfer efficiency (diffusing capacity) frequently give a far more comprehensive picture of the lung's condition.[11]

Pulmonary function testing has become a key component of pulmonary medicine practice because to significant advancements in medical technology and lung physiology during the past 40 years.[12] Early detection, evaluation of the natural history, and response to treatment are all made possible by pulmonary function tests, which provide precise, repeatable evaluation of the respiratory system's functional state and enable measurement of the disease's severity.[13]

HISTORICAL REVIEW OF PULMONARY FUNCTION TESTS

"The following are some of the important landmarks on the evaluation of Pulmonary function tests":[14]

- "Galen conducted a volumetric experiment on human breathing between AD 129 and AD 200.
- Borelli attempted to quantify the volume inspired in a single breath in 1681. To accomplish this, he sucked a liquid through a cylindrical tube.
- In 1718, Jurin J. blew air into a bladder and used Archimedes' principles to

measure the volume of air in the bladder. He recorded a maximum expiration of 3610 ml and a tidal volume of 650 ml.

- Bernovilli D. presented a technique for calculating expired volume in 1749. Abernethy recorded 3150 millilitres of essential capacity in 1793.
- In 1796, Menzies R. calculated the tidal volume using the body plethysmography method.
- Pepys W.H. Jun used two mercury gasometers and one water gasometer in 1799 to determine the tidal volume, which came out to be 270 ml.
- Using a gasometer, Davy H. tested his own vital capacity in 1800 and discovered that it was 3110 ml, his tidal volume was 210 ml, and the hydrogen dilution procedure returned 590 ml as residual volume.
- In 1813, Kentish E. investigated ventilatory volumes in illness using a basic "pulmometer."
- John Hutchinson released a paper in 1852 on his "water spirometer," which is still in use today with just minor modifications. He demonstrated how height and vital capacity are linearly related.
- Wintrich created a modified spirometer in 1854. He came to the conclusion that the vital capacity is determined by three parameters. They are the person's age, height, and weight.
- Smith E. created a portable spirometer in 1859.
- In 1866, Salter equipped the spirometer with a kymograph to record both the time and the volume measured".
- "In 1879, Gad J. invented the Aeroplethysmograph, a pneumatograph that records the volume changes of the thorax during inspiration and expiration in addition to the established parameters."

- "A formula for determining respiratory dead space in terms of alveolar and expired air gases was developed by Christain Bohr in 1890."
- "Brodie T. G. utilised a dry bellow wedge spirometer for the first time in 1902.
- Tissot unveiled the close circuit spirometer in 1904.
- Knipping H.W. presented a standardised spiroergometer method in 1929.
- FEV was first presented by Tiffnean in 1948 as a practical lung function test.

Peak flow meters were first introduced by Wright B.M. and McKerrow C.B. in 1959, and computerised spirometers were first produced in 1990".

PULMNORY FUNCTION TESTS

The phrase "pulmonary function tests" (PFTs) refers to a broad range of procedures or studies that can be carried out with standardised equipment in order to assess lung function. "Simple screening spirometry, formal lung volume measurement, carbon monoxide diffusing capacity, and arterial blood gases are examples of PFTs". The term "complete pulmonary function survey" may be used to describe all of these investigations. These tests offer an objective and quantitative evaluation of the physiological disturbance linked to lung disorders. Specific pathological or etiological diagnoses are not provided by them.[15, 16]

The tests are as follows and can be divided into three groups.[17]

1. Tests to evaluate lung ventilatory function.
2. Examinations to evaluate gas exchange in the lungs.
3. Tests to evaluate how the body transports gases.

A] Tests to Evaluate Lung Ventilatory Functions [16]

1) Evaluation of chest wall and lung expansion a) Pressure change measurement.

For instance, intrapulmonary (intraalveolar) pressure

Intra-thoracic (intra-pleural) pressure

a) Compliance evaluation

Ex: Chest wall and lung compliance

Lung compliance alone.

2) Evaluation of ventilatory abnormalities that are obstructive and restrictive

a) Spirometry is used to measure the static and dynamic lung volumes and capabilities.

b) Airway resistance measurement. This gives a decent picture of i) Normal people's level of physical fitness.

ii) “The kind and degree of lung function abnormalities in patients B) Tests to evaluate gas exchange throughout the lungs.

a) Functional Residual Capacity measurement.

b) Alveolar ventilation uniformity and dead space measurement.

b) Lung Diffusing Capacity Measurement.

C) Evaluating the body's gas transport through tests.

a) Gas tension measurement.

For example, pO2 pCO2 in alveolar, inspired, and expired air.

b) Blood acid-base status and gas tension measurements”.

Lung Volumes:[17]

1) “Tidal Volume (TV): It is the volume of air breathed in or out during quiet respiration. Normal value: 500 ml”.

2) Inspiratory Reserve Volume (IRV): It is the maximum volume of air which can be inspired after complete normal tidal inspiration. Normal value: 2000 to 3200 ml.
3) Expiratory Reserve Volume (ERV): It is the maximum volume of air which can be expired after a normal tidal expiration. Normal value: 750 to 1000 ml.
4) Residual Volume (RV): It is the volume of air which remains in the lungs after a maximal forced expiration. Normal value: 1200 ml.

"Capacities:[17]

1) Inspiratory Capacity (IC): It is the maximum volume of air which can be inspired after complete tidal expiration. Normal value: 2500 to 3700 ml.
   IC = TV + IRV
2) Expiratory Capacity (EC) : It is the maximum volume of air which can be expired after complete tidal inspiration. Normal value: 1250 to 1500 ml.
   EC = TV + ERV
3) Vital Capacity (VC) : It is the maximum volume of air which can be expired from lungs by forceful efforts followed by a maximal inspiration. Normal value: 4.8L in males and 3.2 L in females.
   VC = TV + IRV + ERV"

DYNAMIC LUNG FUNCTION TESTS[17]

1. **Forced Expiratory Volume (Timed Vital Capacity**)

"At the conclusion of the first (FEV1), second (FEV2), or third (FEV3) second, it is the portion of vital capacity that is expelled.

FEV 1% is calculated by multiplying the volume of air exhaled in the first second by 100.

FEV1 = 85% (the first second times 100 is when 85% of the air leaves the lungs).

96% is the FEV2.

FEV3 is 100%.

The speed at which petrol can be pushed into the airways limits FEV1. In obstructive lung diseases, it is decreased. Even in the absence of obstruction, the amplitude of FEV1 is usually decreased in tandem with a decrease in FVC, making FEV1/FVC relevant for diagnosis.

It is often "higher than 75% (0.75) in healthy individuals and lower than 50% (0.5) in cases of increased airway resistance, such as asthma".

2. Maximum Ventilatory Volume

It is the most air that can be forced into or out of the lungs in a minute with the highest voluntary ventilator effort. It is around 170 L/min".

3. Peak Expiratory Flow Rate (PEFR)

It is the volume of air that can be expelled from lungs that are fully expanded as quickly as feasible.

A peak flow meter is used to record the peak expiratory flow rate that is reached. PEFR is a measurement that records the maximum air flow to assess lung efficiency. Age, sex, and build all affect peak expiratory flow rate.

About 10 L/sec (6 to 15 l/sec) is the rate.

It is roughly 400 L/min in a young adult.

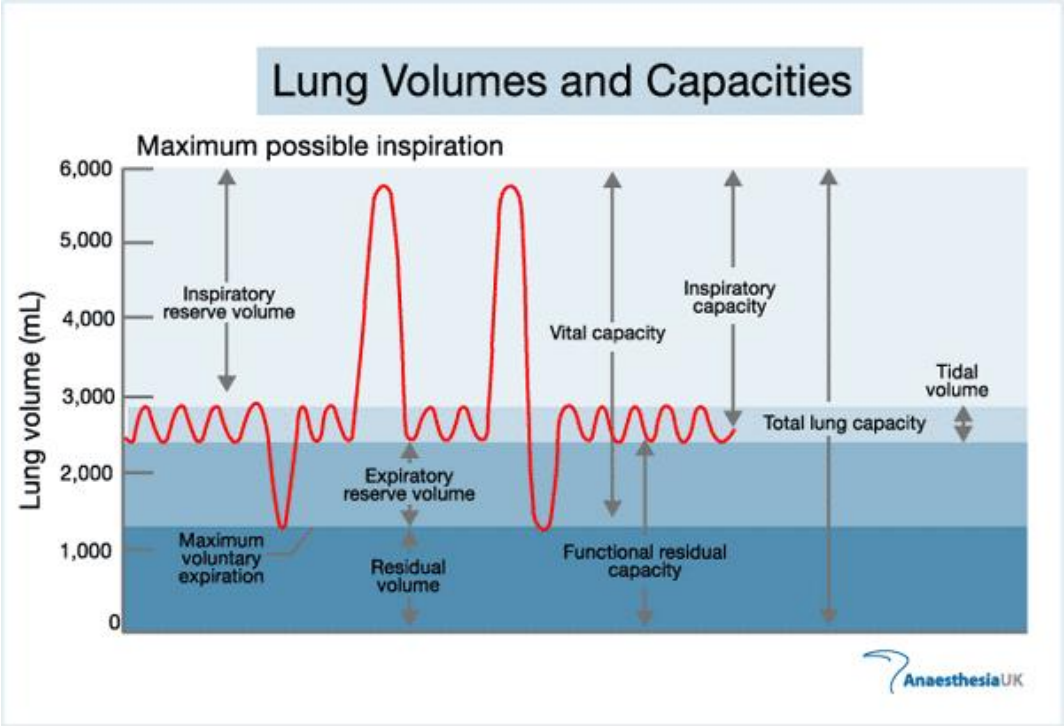
In people with Chronic Obstructive Lung Diseases (COPD), it drops sharply.

4. Maximum Expiratory Pressure (MEP).

Respiratory muscle dysfunction is linked to a variety of respiratory symptoms. Malnutrition, congestive heart failure, multiple sclerosis, motor neurone disorders, and multicore myopathy have all been linked to increasing respiratory muscle

weakening.

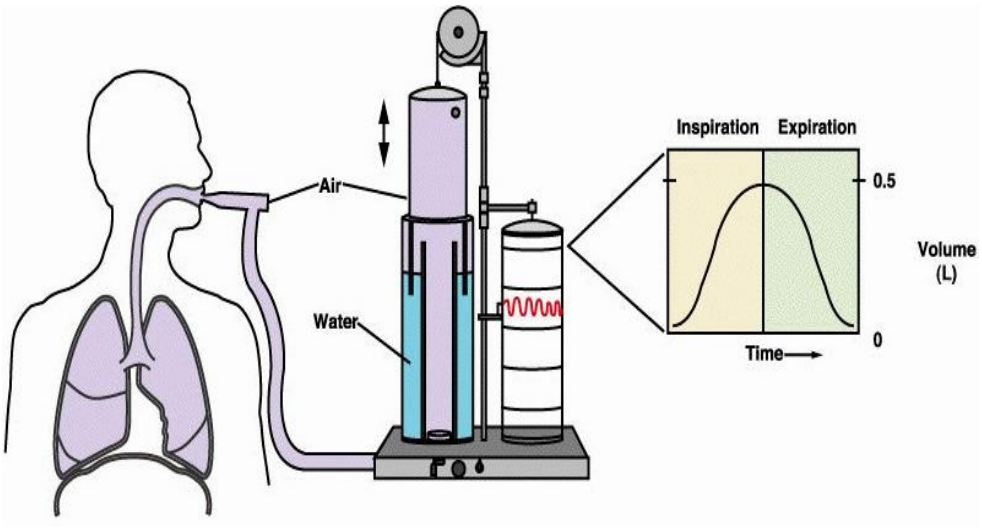
Figure 1: Diagram Showing Different Lung Volumes and Capacities.



SPIROMETRY

The most popular pulmonary function test is spirometry. It keeps track of how much air is inhaled and exhaled as well as how quickly this process occurs. “A spirometer, which is a lengthy piece of tubing with a mouthpiece at one end and a recording mechanism at the other, is the instrument used in this test.” Any level of functional abnormalities, such as restrictive or obstructive pulmonary derangement linked to lung illnesses, can be detected by spirometry. 35 Except for residual volume and functional residual capacity, all lung volumes and capabilities can be assessed with a spirometer.

Figure 2: Simple Spirometer



A spirogram is a visual depiction of bulk air movement that can be either a flow-volume trace or a volume-time trace. “Important visual and numerical information on the mechanical characteristics of the lungs, such as airflow (forced expiratory volume in 1 second [FEV1] and other timed volume) and exhaled lung volume (FVC or SVC), can be obtained from values produced by a basic spirogram.” “The measurement is adjusted for body temperature and pressure of the gas saturated with water vapour, and is commonly given in litres for volumes or litres per second for flows.” Spirogram data offer crucial hints for differentiating restrictive conditions, which usually reduce total lung volumes, such pulmonary fibrosis and neuromuscular illness, from obstructive pulmonary disorders, which usually reduce airflow, like asthma and emphysema.[16]

- ✧ **Indications for Spirometry**[17, 18]

- **Diagnostic**

  To evaluate symptoms

  § Cough

  § Dyspnea

§ Orthopnea

§ Phlegm production

§ Wheezing

- **To evaluate signs**

  § Chest deformity

  § Cyanosis

  § Diminished breath sounds

  § Expiratory slowing

  § Over inflation

  § Unexplained crackles

- **To evaluate abnormal laboratory tests**

  § Abnormal chest radiographs

  § “Hypercapnia

  § Hypoxemia

  § Polycythemia”

- **To measure the effect of disease on pulmonary function**

  To screen persons at risk tor pulmonary diseases

  § Smokers

  § Persons in occupations with exposures to injurious SL1bStaflC

Some routine physical examinations

- To assess preoperative risk
- To assess prognosis (lung transplant, etc.)
- To assess health status before enrolment in strenuous physical activity programs

✧ **Patho- physiological factors affecting the lung functions:**

Physiological factors:

- Age, gender, height, weight, BMI, ethnicity, pregnancy, posture, exercise
- Customary activity, time of day, season, climate and geographical
- Location
- Diet (malnutrition)
- Air pollution (occupational/environmental exposure)
- Smoking
- Chronic obstructive pulmonary disease (COPD), interstitial lung disease
- Coronary artery disease
- Diabetes mellitus/impaired glucose tolerance/hormonal disorders
- Neuromuscular disorders (Guillain barre syndrome, Myasthenia gravis.)

CIRRHOSIS OF LIVER

Definition

The histological formation of regenerating nodules encircled by fibrous bands in response to chronic liver injury is known as cirrhosis, and it causes portal hypertension and end-stage liver disease.[19]

Etiology

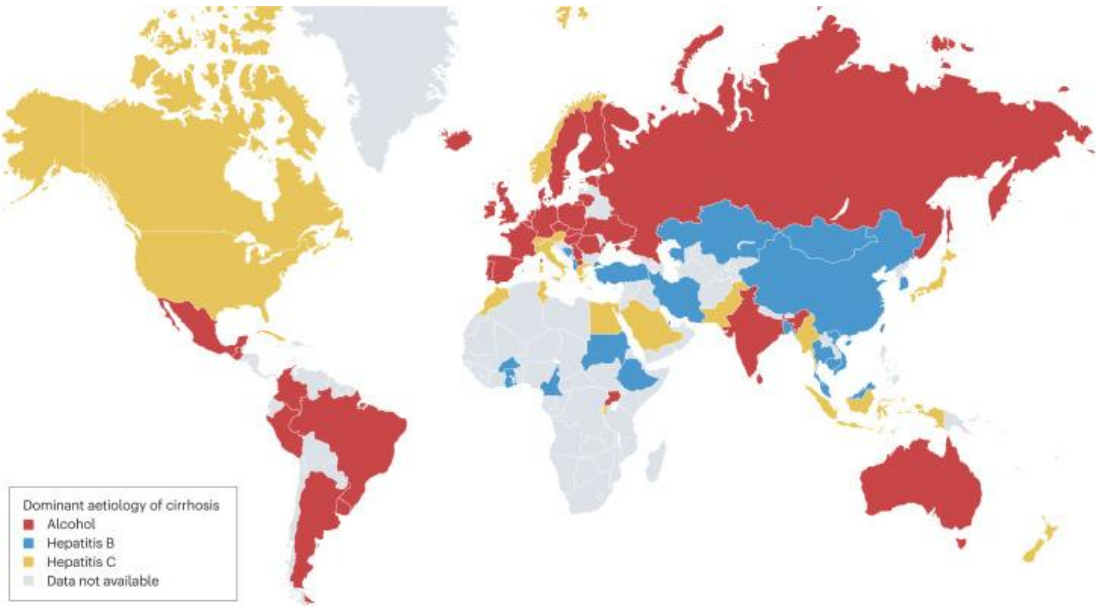
Cirrhosis is typically the result of chronic liver disorders. “Hepatitis C virus (HCV), alcoholic liver disease, and nonalcoholic steatohepatitis (NASH) are the most prevalent causes of cirrhosis in the developed world.” In contrast, the most prevalent causes in the developing world are HCV and the hepatitis B virus (HBV). “Hemochromatosis, Wilson disease, alpha-1 antitrypsin deficiency, Budd-Chiari syndrome, autoimmune hepatitis, primary biliary cholangitis, primary sclerosing cholangitis, drug-induced liver cirrhosis, and chronic right-sided heart failure are

additional causes of cirrhosis. The term "cryptogenic cirrhosis" refers to cirrhosis with an unknown cause."[20]

Figure 3: Aetiology of Liver Cirrhosis

In developed countries, common causes of cirrhosis include:
Chronic viral hepatitis (hepatitis B & C)
Alcohol-associated liver disease
Hemochromatosis
Non alcohol-associated fatty liver disease
Less common causes include:
Autoimmune hepatitis
Primary and secondary biliary cirrhosis
Primary sclerosing cholangitis
Medications (eg, methotrexate, isoniazid)
Wilson disease
Alpha-1 antitrypsin deficiency
Celiac disease
Idiopathic adulthood ductopenia
Granulomatous liver disease
Idiopathic portal fibrosis
Polycystic liver disease
Infection (eg, brucellosis, syphilis, echinococcosis)
Right-sided heart failure
Hereditary hemorrhagic telangiectasia
Veno-occlusive disease

Figure 4: "Data were obtained from a systematic review of cirrhosis that included studies published during the period 1993–2021."[23]



Epidemiology

The "Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2017 reports the most latest information on the prevalence of cirrhosis worldwide.

"Based on combined epidemiological data from 195 nations and territories, stratified by aetiology, age, and sex, the GBD 2017" estimated the burden of cirrhosis from 1990 to 2017." The prevalence statistics are shown as numerical values together with 95% UIs for age-standardized or age-specific rates per 100,000 people. "An estimated 10.6 (10.3-10.9) million cases of decompensated cirrhosis and 112 (107-119) million cases of compensated cirrhosis were reported globally in 2017."[21]

"Hepatitis B virus (HBV) (29%), hepatitis C virus (HCV) (9%), non-alcoholic fatty liver disease (NAFLD) (60%) and alcoholic liver disease (ALD) (2%) were the leading causes of chronic liver disease (CLD), which affected 1.6 billion people globally in 2017." Additionally, cirrhosis contributed to approximately 132 million deaths (95% UI: 127–145) worldwide in 2017, with 883,000 deaths (838,000–967,000, 66.7%) among men and 440,000 deaths (416,000–518,000, 33%) among women. In 1990, 899,000 deaths in both sexes were attributed to CLD (829,000-948,000). This is a noteworthy rise. Between 1990 and 2017, these deaths accounted for 2.4% (2.3-2.6) of all deaths worldwide, up from 1.9% (1.8-2.0) in 1990. "The estimated incidence of cirrhosis is 16.5 cases per 100,000 in East Asia and 23.6 cases per 100,000 in Southeast Asia." There were 20.7 cases of cirrhosis per 100,000 people in 2015, up 13% from 2000, according to data from the Global Burden of Disease survey. Over the past 20 years, cirrhosis has become 1.5–2 times more common.[22, 23]

Pathophysiology

"Hepatocytes and sinusoidal lining cells, such as hepatic stellate cells (HSCs), sinusoidal endothelial cells (SECs), and Kupffer cells (KCs), are among the several

cells involved in liver cirrhosis." Vitamin A is stored by HSCs, which are a component of the liver sinusoids' wall. Fibrosis is the outcome of these cells becoming activated, changing into myofibroblasts, and beginning to deposit collagen after being exposed to inflammatory cytokines. The endothelium lining is formed by SECs, which are distinguished by the fenestrations they create in the wall that permit the hepatocytes and sinusoids to exchange nutrients and fluid. [24] Chronic alcohol consumption can cause defenestration of the sinusoidal wall, which can lead to perisinusoidal fibrosis. [25] The sinusoidal wall is also lined with satellite macrophages called KCs. According to research using animal models, they contribute to liver fibrosis by serving as virus-presenting cells and producing toxic mediators in response to damaging stimuli. [26] Because injured hepatocytes release inflammatory mediators and reactive oxygen species that can encourage activated HSCs and liver fibrosis, hepatocytes are also implicated in the pathophysiology of cirrhosis. [27] The development of portal hypertension and hyperdynamic circulation is the primary cause of morbidity and death in people with cirrhosis. Fibrosis and intrahepatocellular vasoregulatory alterations cause portal hypertension, which in turn causes the establishment of collateral circulation and hyperdynamic circulation. SECs produce endothelin-1 (ET-1) and nitric oxide (NO) intrahepatically, which interact with HSCs to modulate sinusoidal blood flow and relax or contract the sinusoids, respectively. When NO production declines in cirrhosis patients, ET-1 synthesis rises and the sensitivity of its receptors increases. Portal hypertension is brought on by increased intrahepatic vasoconstriction and resistance. The increase in vascular resistance is enhanced by vascular remodelling brought on by the contractile actions of HSCs in the sinusoids. Collateral circulation is created to offset this rise in intrahepatic pressure. The converse occurs in splanchnic and systemic circulation, where an

increase in NO production results in splanchnic and systemic vasodilation as well as a decrease in systemic vascular resistance. This causes hyperdynamic circulation and retention of water and salt by activating the renin-angiotensin-aldosterone pathway. “As a result, in cirrhosis with portal hypertension, sinusoidal vasoconstriction and splanchnic (systemic) vasodilation occur due to a renin-excess of NO extrahepatically in the splanchnic and systemic circulation and a depletion of vasodilators (mostly NO) intrahepatically.” By boosting the venous return to the heart, the collaterals also aid in the hyperdynamic circulation..[28]

Histopathology[29]

“Cirrhosis is classified based on morphology or etiology.”

- **Morphology Classification**

Cirrhosis can have one of three morphologies: micronodular, macronodular, or mixed. “The etiologic classification is more clinically relevant than this one. Alcohol-related cirrhosis, hemochromatosis, hepatic venous outflow blockage, chronic biliary obstruction, jejunoileal bypass, and Indian childhood cirrhosis are all examples of micronodular cirrhosis, which is characterised by homogeneous nodules that are less than 3 mm in diameter.” “Primary biliary cholangitis, alpha-1 antitrypsin deficiency, and hepatitis B and C can all cause macrodular cirrhosis, which is characterised by irregular nodules that vary more than 3 mm in diameter.” When both micronodular and macronodular cirrhosis characteristics are present, the condition is known as mixed cirrhosis. “Typically, micronodular cirrhosis develops into macronodular cirrhosis over time.”

Etiology Classification

"Based on the cause of cirrhosis which is sub-classified as follows:

- oHepatitis B, C, and D are viral
- Toxins: drugs and alcohol
- Hepatitis caused by autoimmune disease
- Cholestatic conditions include primary sclerosing cholangitis and primary biliary cholangitis.
- Heart cirrhosis, sinusoidal obstruction syndrome, and Vascular-Budd-Chiari syndrome Metabolic: Wilson disease, hemochromatosis, NASH, alpha-1 antitrypsin insufficiency, and cryptogenic cirrhosis".

History and Physical

Depending on whether they have clinically compensated or decompensated cirrhosis, patients may be asymptomatic or symptomatic. Patients with compensated cirrhosis typically have no symptoms, and lab work, physical examinations, or imaging may unintentionally reveal the illness. A modest to moderate increase in gamma-glutamyl transpeptidase or aminotransferases, along with a potential enlarged liver or spleen, is one of the usual results. Conversely, individuals with decompensated cirrhosis typically have a variety of symptoms that stem from a confluence of portal hypertension and liver disease. A patient with cirrhosis enters a decompensated phase of the disease when they are diagnosed with ascites, jaundice, hepatic encephalopathy, variceal haemorrhage, or hepatocellular cancer. Hepatorenal syndrome and spontaneous bacterial peritonitis are additional cirrhosis complications that affect people with ascites.

Multiple Organs Affected

Gastrointestinal

Caput medusa may occur from portal hypertension-induced ascites, hepatosplenomegaly, and prominence of the periumbilical abdominal veins. “Esophageal varices, which have a mortality risk of at least 20% six weeks following a bleeding event, are another cirrhosis consequence brought on by increased blood flow in the collateral circulation.”[30] Individuals with chronic liver illness are more likely to develop gallstones, and those with alcoholic cirrhosis are more likely to develop small bowel bacterial overgrowth and chronic pancreatitis..[31, 32]

Hematologic

Haemolytic anaemia (spur cell anaemia in severe alcoholic liver disease), hypersplenism, and folate deficiency can all cause anaemia. Patients with cirrhosis may experience hemosiderosis from many causes, impaired coagulation, disseminated intravascular coagulation, and pancytopenia from hypersplenism in portal hypertension.

Renal

Because of systemic hypotension and renal vasoconstriction, which results in the underfilling phenomena, patients with cirrhosis are more likely to develop hepatorenal syndrome. Reduced effective blood flow to the kidneys due to splanchnic vasodilation in cirrhosis triggers the renin-angiotensin-aldosterone pathway, which results in water and salt retention as well as renal vascular constriction. [33] This impact, however, is insufficient to counteract the systemic vasodilation brought on by cirrhosis, which results in renal hypoperfusion and is exacerbated by renal vasoconstriction, ultimately leading to renal failure.[34]

Pulmonary

Lowered oxygen saturation, ventilation-perfusion mismatch, decreased pulmonary diffusion capacity, hepatopulmonary syndrome, portopulmonary hypertension, hepatic hydrothorax, and hyperventilation are all signs of cirrhosis.

Skin

Patients with cirrhosis who have hyperestrogenemia may develop spider nevi, which are major arterioles encircled by numerous smaller arteries that resemble spiders. Spider nevi and an elevated estrogen-to-free testosterone ratio are the results of a sex hormone imbalance brought on by liver failure. [35] Another skin symptom of cirrhosis that is linked to hyperestrogenemia is palmar erythema. "Jaundice is a yellowish discolouration of the skin and mucous membranes that occurs in decompensated cirrhosis and when the blood bilirubin level is higher than 3 mg/dL."

Endocrine

Those who have alcoholic liver cirrhosis may get gynaecomastia and hypogonadism. The hypersensitivity of oestrogen and androgen receptors observed in cirrhotic patients is the primary cause of the multifactorial pathophysiology. The emergence of these disorders has also been linked to hypothalamic pituitary dysfunction. [36] Males with hypogonadism may experience feminisation, loss of secondary sexual traits, and diminished desire and impotence. Infertility, abnormal menstrual flow, and amenorrhoea can all affect women.

Nail Changes

Clubbing, Dupuytren contracture, and hypertrophic osteoarthropathy are seen. Terry nails, Muehrcke nails, and azure lunules (Wilson illness) are other nail abnormalities.

Others

"Hepatic encephalopathy in cirrhosis can manifest as foetal hepaticus (sweet, musty breath smell caused by high blood levels of dimethyl sulphide and ketones) and asterixis (flapping tremor when the arms are extended and the hands are dorsiflexed." [37] Muscle cramping, umbilical herniation, decreased lean muscle mass, and hyperdynamic circulation are all consequences of cirrhosis. "Patients with cirrhosis may have symptoms of portal hypertension (ascites, splenomegaly, caput medusae, Cruveilhier-Baumgarten murmur-epiticular venous hum), signs of hepatic encephalopathy (confusion, asterixis, and foetor hepaticus), stigmata of chronic liver disease (spider telangiectasias, palmar erythema, Dupuytren contractures, gynaecomastia, testicular atrophy), and other characteristics like jaundice, bilateral parotid enlargement, and sparse chest/axillary hair."

Evaluation

Lab Findings

"Normal levels do not rule out cirrhosis, although aminotransferases are often mildly to moderately increased, with aspartate aminotransferase (AST) being higher than alanine aminotransferase (ALT)." [38] The AST/ALT ratio is less than 1 in the majority of chronic hepatitis types (alcoholic hepatitis excluded). This AST/ALT ratio reverses as chronic hepatitis develops into cirrhosis. "Cholestatic diseases are associated with higher levels of alkaline phosphatase (ALP), 5'-nucleotidase, and gamma-glutamyl transferase (GGT). Albumin is low because the liver produces it and its functional capacity declines, while coagulation factor deficiencies and bilirubin cause an increase in prothrombin time (PT)." PT and serum albumin are therefore reliable markers of artificial hepatic function. While normochromic anaemia is observed, alcoholic liver cirrhosis can cause macrocytic anaemia. Alcohol's inhibition

of the bone marrow and the bigger spleen's sequestration also cause leukopenia and thrombocytopenia. [39] Impaired liver clearance typically results in increased immunoglobulins, particularly the gamma fraction.[40]

Specific Labs to Investigate Newly Diagnosed Cirrhosis

"Anti-nuclear antibodies [ANA], anti-smooth muscle antibodies (ASMA), anti-liver-kidney microsomal antibodies type 1 (ALKM-1), and serum IgG immunoglobulins for autoimmune hepatitis, as well as anti-mitochondrial antibodies for primary biliary cholangitis, can be ordered using serology and PCR techniques for viral hepatitis and autoimmune antibodies." Other helpful tests include serum alpha-fetoprotein for hepatocellular carcinoma (HCC), "ferritin and transferrin saturation for hemochromatosis, ceruloplasmin, and urine copper for Wilson disease, alpha 1-antitrypsin level, and protease inhibitor phenotype for alpha 1-antitrypsin deficiency."

Imaging and Liver Biopsy

Labs are utilised in conjunction with a number of imaging modalities to aid in the diagnosis of cirrhosis. These consist of transient elastography (fibroscan), CT, MRI, and ultrasound. One accessible, affordable, and noninvasive method for assessing cirrhosis is ultrasonography. It can identify liver nodules and elevated echogenicity, which are indicative of cirrhosis, but it is not specific because similar characteristics can also be found in fatty liver. [41] "The caudate lobe width to right lobe width ratio, which often rises in cirrhosis, can also be ascertained."[42] In individuals with cirrhosis, it is also a helpful screening tool for HCC. The mesenteric, portal, and hepatic veins' patency can be evaluated with the use of duplex Doppler ultrasonography. On the other hand, MRI is better than CT at detecting vascular lesions and HCC. [43] If an MRC (magnetic resonance cholangiography) is performed, MRI can also be used to determine the amount of iron and fat accumulation in the

liver for biliary obstruction, steatosis, and hemochromatosis. However, "MRI is costly and not widely accessible. A noninvasive technique called transient elastography (fibroscan) measures liver stiffness, which is correlated with fibrosis, using high-velocity ultrasound pulses. A technetium-99m sulphur colloid colloid liver spleen scan in cirrhosis may reveal more colloid uptake in the spleen and bone marrow than in the liver". On esophagogastroduodenoscopy (EGD), varices in the stomach or oesophagus indicate portal hypertension. "The gold standard for identifying cirrhosis and determining the level of inflammation (grade) and fibrosis (stage) in the illness is a liver biopsy. However, sample flaws might sometimes cause it to miss the diagnosis."[44] Fibrosis and nodules must be present for a biopsy to diagnose cirrhosis. There are three different types of nodules: micronodular, macronodular, and mixed. "Each type of nodule is a risk factor for increased hepatic venous pressure gradient (HVPG) and more severe illness."[45] Patients with substantial fibrosis or cirrhosis are distinguished from those with little or mild fibrosis using noninvasive tests that use direct and indirect blood indicators.[46]

Complications

- Hepatic cirrhosis can have the following complications:
- Portal hypertension • Abdominal and lower extremity oedema

Hepatic encephalopathy, infections, haemorrhage, splenomegaly, and jaundice[47]

Prognosis

According to "predictive models for cirrhosis prognosis, individuals with compensated cirrhosis have a 47% 10-year survival rate; however, after a decompensating event, this falls to 16%. Serum albumin, bilirubin, PT, ascites, and hepatic encephalopathy are used in the Child-Turcotte-Pugh (CTP) grading or classification to divide cirrhosis patients into classes A, B, and C. "These classes have

survival rates of 100% and 85% at 1 and 2 years (A), 80% and 60% at B, and 45% and 35% at C. Another model for predicting the short-term mortality of cirrhosis patients is the model for end-stage liver disease (MELD) score. It forecasts mortality over the following three months using serum bilirubin, creatinine, and INR. In the United States, the MELD score—more recently, the MELDNa score—is used to determine the priority of organ allocation for liver transplantation in patients with cirrhosis. [48] When medical treatment is ineffective for decompensated cirrhosis, liver transplantation may be necessary. Following a liver transplant, the 1-year and 5-year survival rates are roughly 85% and 72%, respectively. Following a transplant, the underlying liver disease may recur. Immunosuppressive medications' long-term adverse effects are another factor contributing to transplant recipients' morbidity".[49]

LIVER CIRRHOSIS AND PULMONARY DYSFUNCTION

HEPATOPULMONARY SYNDROME

In 1977, hepatopulmonary syndrome (HPS) was originally postulated based on clinical and postmortem results. Liver cirrhosis patients' autopsies revealed dilated pulmonary vasculature, which was assumed to be the origin of some of the pulmonary symptoms observed in individuals with chronic liver disease. When severe liver disease or portal hypertension are present, HPS is characterised by decreased arterial oxygen saturation brought on by dilated pulmonary vasculature.[50]

Diagnostic criteria

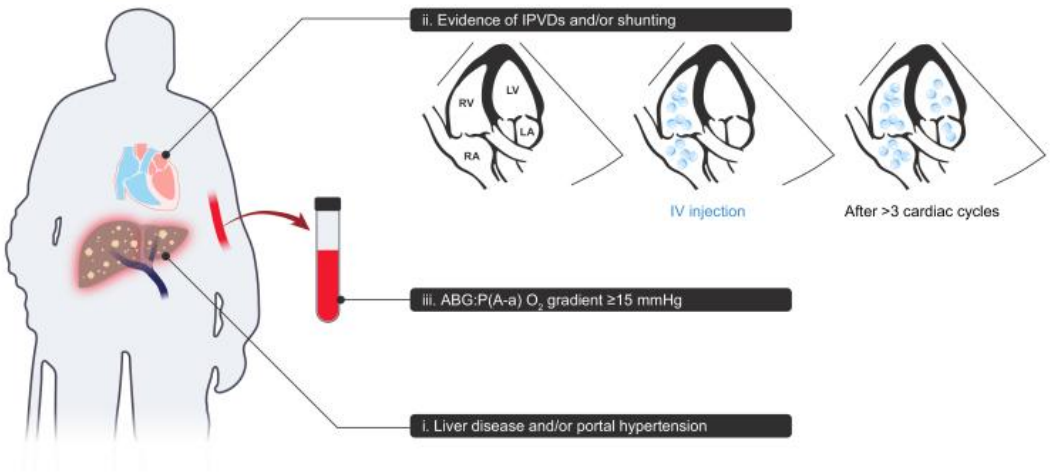
The following are the diagnostic standards for HPS:

- "Alveolar-arterial oxygen gradient (A-aO2): ≥15 mm while breathing room air, or partial pressure of oxygen (PaO2): Less than 80 mm Hg; in patients over 64, A-aO2 >20 mm Hg is deemed diagnostic (they should be resting in a seated position)."

- "Pulmonary vascular dilatation: shown by radioactive lung-perfusion scanning (which displays a brain shunt fraction more than 6%) or positive contrast-enhanced echocardiography."
- Portal hypertension: cirrhosis-related or not51
    - PaO2 levels determine how severe HPS is:

- "Mild: breathing room air with PaO2 ≥80 mm Hg and A-aO2 ≥15 mm Hg"
- "Moderate: breathing room air with PaO2 ≥60 mm Hg to <80 mm Hg and A-aO2 ≥15 mm Hg"
- "Severe: breathing room air with PaO2 ≥50 mm Hg to <60 mm Hg and A-aO2 ≥15 mm Hg"
- "Very severe: PaO2 <50 mm Hg with A-aO2 ≥15 mm Hg when breathing room air or PaO2 <300 mm Hg while breathing 100% oxygen."[52]

Figure 5: HPS diagnostic standards. i) Portal hypertension and/or liver illness. ii) Proof of shunting and/or IPVDs. Contrast-enhanced echocardiography is the gold standard. IPVDs or shunts are indicated by the "delayed" occurrence of microbubbles in the left heart following intravenous injection, which occurs three or more cardiac cycles after being observed in the right heart. iii) P(A-a)O2 gradient ≥15 mmHg, as established by ABG analysis (or >20 in the case of ≥65 years of age). Intrapulmonary vascular dilatations (IPVDs); arterial blood gas (ABG); hepatopulmonary syndrome (HPS); and the alveolar-arterial oxygenation gradient (P(A-a)O2).



Etiology

The most frequent cause of HPS is portal hypertension brought on by cirrhosis or chronic liver disease. However, HPS can also result from portal hypertension in the absence of underlying liver illness. One uncommon cause of HPS is acute liver disease, such as acute hepatitis that leads to acute liver failure. “There is no correlation between the severity of liver disease and the existence or severity of HPS.”

Epidemiology

White people are more likely than Black or Hispanic people to have HPS, while patients who smoke are less likely to have it. According to data from liver transplantation centres, the incidence of HPS in cirrhosis patients varied from 5% to 32%. 53 HPS is seldom observed in youngsters and is more common in people with significant hepatic impairment and cirrhotic portal hypertension.[54]

Pathophysiology

The primary aetiology of HPS is believed to be pulmonary vascular dilatation brought on by an imbalance between vasodilators and vasoconstrictors. Vasodilation's precise process is unclear, and numerous studies are being conducted to clarify it. Stress causes the liver to produce more endothelin 1 (ET1) and pulmonary endothelin B (ETB), which stimulates the lungs' pulmonary endothelial nitric oxide

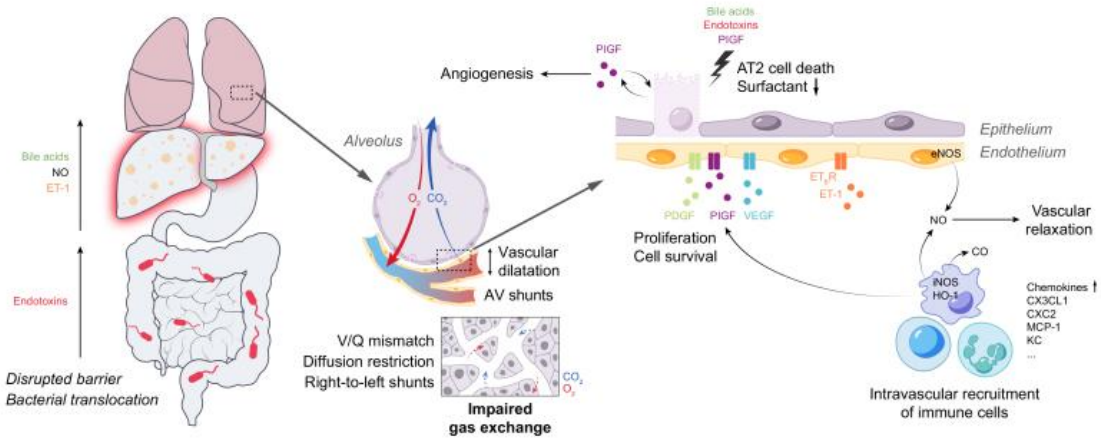
synthetase (eNOS). Nitric oxide (NO), a strong vasodilator, is produced in greater amounts when eNOS is stimulated. In individuals with liver illness, intestinal bacterial translocation and endotoxemia result in a significant buildup of monocytes and macrophages in the lungs. "In pulmonary arteries, these macrophages release tumour necrosis factor-alpha (TNF-alpha), which triggers the activation of inducible nitric oxide synthetase (iNOS)." Increased nitric oxide (NO) generation is another effect of iNOS activation. Elevated heme oxygenase levels are caused by bacterial accumulation and elevated NO. Heme oxygenase breaks down heme, which increases the generation of carbon monoxide (CO). This enhanced generation of NO and CO, which are strong vasodilators, is essential for pulmonary vasodilation. Additionally, vascular endothelial growth factor (VEGF) is activated by monocytes, macrophages, and TNF alpha, which increases angiogenesis in the pulmonary vasculature. [55] A mismatch between ventilation and perfusion results from arteriovenous (AV) shunt development in the pulmonary vasculature caused by vasodilation and angiogenesis. "In HPS, the pulmonary capillaries enlarge to a diameter of 15 to 500 mm, as opposed to their typical diameter of 8 to 15 mm."[56] "Reduced transit time for blood cells and a significant volume of blood flowing through the pulmonary vasculature without undergoing gas exchange are the results of pulmonary vascular dilatation." Gas exchange does not occur in these blood cells because some blood may flow through AV shunts without coming into contact with alveoli. There has also been evidence of thicker pulmonary capillary walls, which impairs gas transport.

The ventilation-perfusion mismatch caused by pulmonary vasodilation, AV shunts, and reduced diffusion results in hypoxaemia and an elevated alveolar-arterial gradient. 57 The most noticeable pulmonary vasodilation occurs in the bases of the lungs, which helps to explain HPS symptoms like orthodeoxia and platypnea.

The location of dilated pulmonary vessels has led to the identification of two forms of HPS:

- Type I: Precapillary vascular dilatation close to the lungs' gas exchange units; more oxygen raises PaO2 in this kind of HPS.
- "Type II: More vascular dilatation results in arteriovenous shunts away from the lungs' gas exchange units; more oxygen is ineffective."[58]

Figure 6: "The pathogenesis and pathophysiology of HPS The development of IPVDs and intrapulmonary shunting in HPS is caused by a complicated interplay between the liver, the stomach, and the lungs that primarily affects pulmonary endothelial cells, immune cells, and respiratory epithelial cells. These conditions lead to right-to-left shunting, diffusion limitation, and V/Q mismatch, which hinder gas exchange and cause hypoxaemia. The most significant underlying mechanisms and possible targets for treatment are bacterial translocation with pulmonary intravascular recruitment of immune cells, pulmonary endothelial dysfunction, angiogenesis, and AT2 cell dysfunction. AV stands for arteriovenous; CO for carbon monoxide; HPS for hepatopulmonary syndrome; NO for nitric oxide; V/Q for ventilation-perfusion; and AT2 for alveolar type II."



History and Physical

When liver illness is present, the patient typically has dyspnoea. Dyspnoea has a sneaky start and gets worse when you push yourself. The majority of individuals are asymptomatic in the early stages. Chronic liver disease symptoms and indicators may be present in the patient. Other cardiopulmonary conditions may co-occur with HPS, exacerbating problems in breathing and perfusion. The following may be revealed by the physical examination:

- Digital clubbing[59]
- Cyanosis
- Diffuse telangiectasia: Spider naevi have been linked to HPS in a number of studies. [60]
- "Orthodeoxia: A drop in PaO2 of more than 5% or more than 4 mm Hg when going from a supine to an upright position; this condition is highly specific for HPS in the presence of liver disease; its sensitivity is low but rises with the severity of HPS."
- "Plasypnea: A worsening of dyspnoea when going from a supine to an upright position."

Evaluation[61]

"There are several methods of evaluating patients for HPS."

Pulse Oximeter

"The first step in screening for HPS is measuring PaO2 with a pulse oximeter. A screen is deemed positive if the O2 saturation is less than 96%, which indicates PaO2 less than 70 mm Hg." In order to ascertain PaO2 and A-aO2, the patient should have arterial blood gas (ABG) analysis if the screen comes up positive.

Contrast-enhanced Echocardiography

"The most reliable method for identifying pulmonary vascular dilatation is contrast-enhanced echocardiography with agitated saline." To create microbubbles larger than 10 micrometres in diameter, regular saline is shaken. Simultaneous transthoracic echocardiography (TTE) is carried out while normal saline is injected into an arm peripheral vein. Microbubbles are typically absorbed by the alveoli after becoming caught in the pulmonary circulation. TTE in the left atrial chamber shows that microbubbles avoid pulmonary capture and make their way to the heart's left atria when pulmonary dilatation and AV shunts are present. "Pulmonary vasodilatation is indicated by the formation of microbubbles in the left atria during the fourth and sixth cardiac cycles. Intracardiac shunting is evident if the microbubbles on the left side of the heart form prior to the third cardiac cycle."

Transesophageal Echocardiogram

For the diagnosis of intracardiac shunting and pulmonary dilatation, a transesophageal echocardiogram examination is more accurate than a transthoracic echocardiography. However, because many patients with cirrhosis and portal hypertension have esophageal varices, this test is more intrusive and dangerous.

Radioactive Lung Perfusion Scanning

An additional test to confirm pulmonary vascular dilation is radioactive lung perfusion scanning. "It is less sensitive than contrast-enhanced echocardiography, though. Intracardiac and intrapulmonary shunting are not differentiated by this test." In individuals with concomitant lung disease, it could be helpful in determining whether HPS is causing hypoxaemia. "Aggregates of radiolabeled albumin, about 20 micrometres in diameter, are injected into the peripheral vein. Particles of this size are typically caught in the pulmonary microvasculature, and scintigraphy shows that the

lungs have almost total uptake." A portion of the albumin enters the systemic circulation through the pulmonary vasculature when there is significant intrapulmonary shunting. The shunt percent can be calculated because scintigraphy can show uptake in organs other than the lung. A brain shunt fraction more than 6% is deemed noteworthy.

Pulmonary Angiography

Type I and type II HPS can be diagnosed and differentiated using pulmonary angiography. However, it is not a favoured way of diagnosis because it is a more costly and invasive test. Additionally, compared to contrast-enhanced echocardiography using agitated saline, it is less sensitive.

Additional Tests

"Additional tests include chest X-rays, computed tomography (CT), and pulmonary function tests:"

- **"Chest X-ray:** May be normal or show increased bibasilar nodular opacities coinciding with increased pulmonary dilatation (can exclude coexistent pulmonary pathology)"
- **"CT of the chest:** May show enlarged dilated vessels; usually done to exclude pulmonary pathology"
- **Arterial Blood Gas**[62]

"A popular diagnostic technique for determining the partial pressures of gases in blood as well as the acid-base content is blood gas analysis." Providers can understand respiratory, circulatory, and metabolic issues by knowing how to use and comprehend blood gas analysis.

"Blood drawn from any part of the circulatory system (artery, vein, or capillary) can be subjected to a "blood gas analysis". Blood drawn from an artery is

specifically tested using an arterial blood gas (ABG). The patient's partial pressures of carbon dioxide (PaCO2) and oxygen (PaO2) are evaluated by an ABG analysis. The oxygenation state is shown by PaO2, while the ventilation status (acute or chronic respiratory failure) is indicated by PaCO2. Acid-base balance, hypoventilation (slow or shallow breathing), and hyperventilation (rapid or deep breathing) all have an impact on PaCO2. While end-tidal carbon dioxide monitoring" and pulse oximetry are non-invasive methods for evaluating ventilation and oxygenation, respectively, ABG analysis is the gold standard.

The majority of AG analysers use direct measurements of pH and PaCO2 to evaluate "the acid-base balance. The serum bicarbonate (HCO3) and base surplus or deficit are determined using a derivative of the Hasselbach equation. Because the equation does not account for the blood CO2, this computation often produces a difference from the measured value. All of the CO2 in serum, including dissolved CO2, carbamino compounds, and carbonic acid, is released by the powerful alkali used to detect HCO3. This measurement, which is based on a normal chemistry study, is probably going to be referred to as a "total CO2" because it only takes into account dissolved CO2. As a result, the difference will be around 1.2 mmol/L. However, particularly in severely ill patients, there may be a more significant discrepancy between the measured number and the ABG".

The calculation needs to be properly interpreted in accordance with institutional norms and "has been contested as both accurate and erroneous depending on the study, machine, or calibration utilised".

Arterial blood gases are commonly ordered by emergency medicine, pulmonology, anaesthesiology, and intensivists. "They can also be utilised in other therapeutic contexts. ARDS, severe sepsis, septic shock, hypovolemic shock, diabetic

ketoacidosis, renal tubular acidosis, acute respiratory failure, heart failure, cardiac arrest, asthma, and inborn errors of metabolism are just a few of the conditions that medical professionals assess with an ABG."

Among the elements of ABG are the following:

pH is the blood's measured acid-base balance; PaO2 is the arterial blood's partial pressure of oxygen; PaCO2 is the arterial blood's partial pressure of carbon dioxide; and HCO3 is the arterial blood's computed bicarbonate concentration.

The computed relative excess or deficit of base in arterial blood is known as the "base excess/deficit."

The computed arterial oxygen saturation, or SaO2, is measured unless a co-oximetry is acquired.

Before drawing an ABG from either upper extremity, a modified Allen test is required to ensure adequate collateral flow. Use duplex ultrasonography and pulse oximetry as alternatives. The radial artery, which is superficial and readily palpable over the radial styloid process, is the arterial location that is frequently employed. The femoral artery is the next most frequent location. The unilateral upper extremity selected for the operation is used for the test. Ask the patient to clench a raised fist for 30 seconds while flexing the chosen upper extremity at the elbow. on stop blood flow, apply pressure on the radial and ulnar arteries. The patient may release the raised fist after five seconds. At this point, the palm will seem bleached, white, or pale. After that, the radial artery compression is kept constant while the pressure over the ulnar artery is relaxed. The palm regains its natural colour in 10 to 15 seconds, a sign of sufficient ulnar collateral blood flow. It is an abnormal test and dangerous to puncture the radial artery if the palm does not return to its natural colour. Likewise, ulnar artery pressure is maintained while radial artery pressure is released in order to measure

radial collateral blood flow.

Results, Reporting, and Critical Findings

"Although the range of normal values may change between laboratories and in various age groups, ranging from neonates to the elderly, the following is an accepted normal range of ABG levels of ABG components":

- pH (7.35-7.45)
- 75–100 mm Hg of PaO2
- 35–45 mm Hg of PaCO2
- Base excess/deficit (-4 to +2) • HCO3 (22–26 mEq/L)
- SaO2 (95–100%)

"It is best to read arterial blood gas in a methodical manner. Understanding the degree or severity of anomalies, whether they are acute or chronic, and if the fundamental problem is of metabolic or respiratory origin are all made possible by interpretation." Simplified methods for interpreting ABG findings have been reported in a number of studies. For all provider levels, the Romanski technique of analysis is the most straightforward. This technique aids in identifying the existence of an acid-base disorder, its main contributing factor, and the existence of compensation.

Examining the "pH to determine whether acidemia (pH < 7.35) or alkalemia (pH > 7.45) is present is the first step. Use a pH of 7.40 as the cutoff threshold if the pH is within the typical range of 7.35 to 7.45. Put differently, classify a pH of 7.42 as alkalemia and a pH of 7.37 as acidosis. Next, assess the ABG results' respiratory and metabolic components, or PaCO2 and HCO3, respectively. The respiratory or metabolic acidosis/alkalosis is the primary cause of the acidosis or alkalemia, as indicated by the PaCO2. A respiratory acidosis is indicated by PaCO2 > 40 and a pH < 7.4, whereas a respiratory alkalosis is indicated by PaCO2 < 40 and a pH > 7.4

(however this is sometimes due to anxiety-induced hyperventilation or as a compensatory mechanism for a metabolic acidosis). Next, check for values (PaCO2 or HCO3) that are out of line with the pH to see if there is any indication of compensation for the initial acidosis or alkalosis. Finally, check the PaO2 for any oxygenation anomalies".

- **Pulmonary function tests:** Reduced diffusing capacity for carbon monoxide is commonly shown in pulmonary function tests; however, this is not exclusive to HPS and is often observed in cirrhosis patients. Furthermore, patients with liver illness and HPS have been shown to exhibit mild anomalies, including reduced forced expiratory volume in the first second (FEV1) and forced vital capacity (FVC), with intact FEV1/FVC ratio.[61]

Figure 7: HPS screening and diagnosis Contrast-enhanced echocardiography and arterial blood gas analysis are necessary for the accurate screening and diagnosis of HPS. Although more research and confirmation in "bigger cohorts are required, biomarkers may make it easier to identify HPS in cirrhosis patients. IPVDs (intrapulmonary vascular dilatation); P(A-a)O2 (alveolar-arterial oxygenation gradient); HPS (hepatopulmonary syndrome").

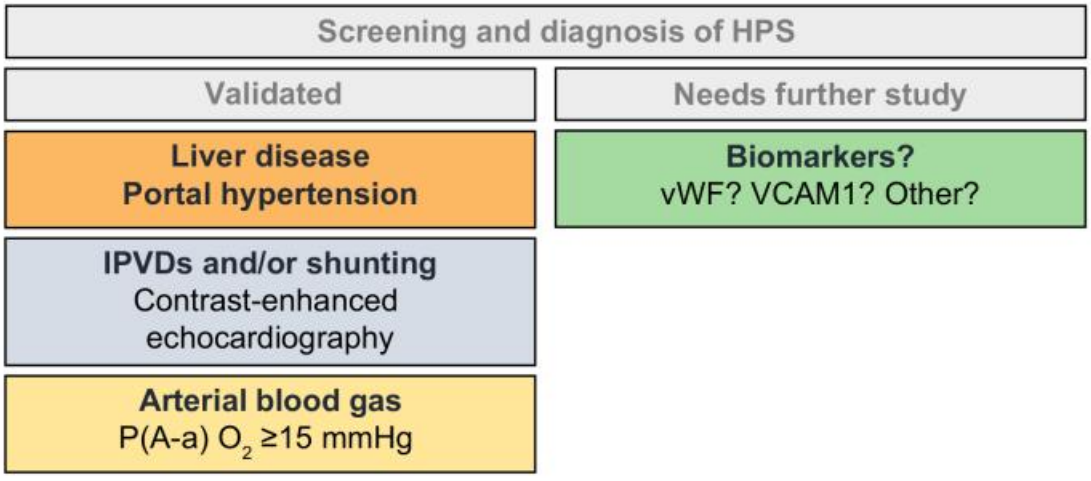


Figure 8: HPS's natural history is often identified by screening; the majority of

individuals have no symptoms or only develop dyspnoea while exerting themselves. A wider P(A-a) O2 gradient is seen by ABG. Usually, hypoxaemia worsens over time. HPS has a dismal prognosis if left untreated. Since LT is the only treatment that can be cured, affected patients' survival rates have significantly increased in recent years. P(A-a)O2, or alveolar-arterial oxygenation gradient; SE, or standard exception; LT, or liver transplantation; HPS, or hepatopulmonary syndrome; and ABG, or arterial blood gas.

HEPATIC HYDROTHORAX[63]

"After ruling out other causes of pleural effusion, such as renal or cardiac decompensation or primary pulmonal disease, hepatic hydrothorax (HH) is defined as a pleural transudate in patients with liver cirrhosis and/or portal hypertension. Because of the restrictive pattern of pulmonary function, patients may exhibit severe clinical symptoms even if they have only a little quantity of pleural effusion." Clinical symptoms are not very precise; patients may experience pleuritic chest discomfort (8%), increased dyspnoea after exertion (7%), nonproductive cough (22%), dizziness and exhaustion due to hypoxaemia (7%), or dyspnoea at rest (34%).

Spontaneous bacterial empyema[63]

Similar to spontaneous bacterial peritonitis (SBP) in the setting of ascites, spontaneous bacterial empyema (SBEM) is a particular HH complication.

Table 1: Key clinical, diagnostic, and treatment choices for spontaneous bacterial empyema and hepatic hydrothorax

	Hepatic hydrothorax	**Spontaneous bacterial empyema**
Definition	Transudative pleural effusion + liver cirrhosis and/or portal hypertension + exclusion of other reasons of pleural effusion (e.g., primary renal, cardiac and pneumological disease)	Spontaneous infection of a preexisting hepatic hydrothorax
Prevalence	5% to 15% in patients with cirrhosis	In 2% of cirrhotic patients, and 10%-16% among cirrhotic patients with hepatic hydrothorax
Diagnostic	Sonography, chest X-ray, diagnostic thoracentesis	diagnostic thoracentesis
Diagnostic criteria of the pleural effusion	1. a total cell count of PMN < 250/µL 2. a total protein concentration < 2.5 g/dL 3. an albumin gradient > 1.1 g/dL between serum and pleural fluid or an albumin quotient (pleura/serum) < 0.6. Optional: a protein quotient < 0.5 (pleura/serum), an LDH gradient < 0.6 (pleura/serum) and comparable values for pH and glucose in serum and	Total cell count of PMN of > 250/µL + a positive pathogen detection or Total cell count of PMN > 500/µL + a negative pathogen detection

	pleural fluid.	
Clinical features	(depending on the amount of pleural effusion) dyspnea at rest/after exertion, non-productive cough, pleuritic chest pain, signs of hypoxemia, respiratory failure and acute tension hydrothorax with cardiac failure	Fever, encephalopathy, hepatorenal decompensation

Porto-pulmonary hypertension[64]

Pulmonary arterial hypertension (PAH) linked to portal hypertension is known as portopulmonary hypertension (PPHT), an uncommon consequence of end-stage liver disease. PPHT's pathophysiology is still a mystery. Numerous pathologic theories were put forth, including:

1) Thromboembolisms originating from the portal venous system;
2) Hyperdynamic pulmonary circulation with increased sheer stress on the pulmonary vascular wall;
3) Increased local inflammation due to elevated cytokine levels associated with the cirrhotic liver;
4) Imbalance of vasoconstrictive and vasodilatory mediators as a result of impaired liver metabolization; and
5) Genetic predisposition.

- Reduced diffusing capacity: PFTs may indicate that the lungs' capability to transfer oxygen into the blood has diminished.

- Decreased airflow: PFTs may demonstrate forced expiratory volume, reduced vital capacity, and forced vital capacity.
- Curvilinear expiratory flow-volume curves: PFTs may indicate a decrease in the ventilation rate.

Pulmonary function testing in patients with liver cirrhosis[65]

Spirometry

Higher Child Pugh scores, "higher MELD scores, pleural effusions, encephalopathy, ascites, hepatic hydrothorax, lower albumin levels, hyperbilirubinemia, and worse exercise capacity, quality of life, and survival rates have all been statistically linked to restrictive spirometric alterations. Furthermore, tight ascites has been linked to a restrictive spirometric pattern. It has been discovered that the Glasgow Alcoholic Hepatitis Scale (GAHS) has a negative correlation with FEV1/FVC values, but the Child-Pugh score has a negative correlation with FEV1, FVC, and FEV1/FVC values".

Diffusing capacity for carbon monoxide

"The most frequent change in lung function found in chronic liver illness is a low DLCO value. The volume of any gas that diffuses over the alveolo-capillary membrane in a single minute under a specific pressure gradient (1 mmHg)" is known as its diffusion capacity. The diffusion capacity of one litre of lung volume, however, is known as DLCO/VA.

Patients with liver cirrhosis have been found to have lower DLCO and DLCO/VA levels. More precisely, it has been demonstrated that DLCO and DLCO/VA have a negative association with the Child-Pugh score, and that DLCO/VA also has a negative link with the MELD score. Furthermore, it has been discovered that DLCO significantly correlates negatively with esophageal varices and

ascites and positively with serum albumin and cholinesterase levels.

Lung volumes

Both gas dilution and whole-body plethysmography can be used to determine TLC and residual volume (RV), which measures the quantity of air remaining in the respiratory tract at the conclusion of a maximal expiration. Functional residual capacity (FRC) is the amount of air that is still in the respiratory system after a typical exhale. As lung volumes rise, so does the FRC. It has been discovered that people with liver cirrhosis had increased, reduced, or normal RV, FRC, and TLC values. More precisely, it has been noted that patients with liver cirrhosis either have normal RV and TLC values or have elevated values, which indicates air trapping. Regarding the relationship between lung volumes and clinicolaboratory features and the degree of liver cirrhosis, TLC has been demonstrated to have a substantial negative correlation with ascites and a significant positive correlation with blood albumin levels. Additionally, it has been discovered that TLC and RV are both significant predictors of ventilator duration as well as ICU and hospital length of stay after liver transplantation, and that TLC and the GAHS scale have a substantial negative connection.

Single breath gas washout

Following a critical capacity inhalation of a used gas-free gas mixture, the exhaled used gas concentration vs. exhaled volume trace shows a quick increase (phase II) followed by a slow-rising alveolar plateau (phase III) and then an abrupt change in slope that marks the start of phase IV. The volume at the beginning of phase I is represented by the closing volume (CV). Although it is unknown if these changes in CV are related to the severity of the disease, it has been observed that patients with liver cirrhosis have higher CVs, which may indicate that tiny airways

may narrow or close in these patients.

Airway occlusion pressure 0.1 sec after the onset of inspiratory flow

"The negative airway pressure that develops during the first 100 milliseconds of an obstructed inspiration is known as the airway occlusion pressure 0.1 seconds after the commencement of inspiratory flow (P0.1). One important predictor of breathing functions is the neuromuscular activation of the respiratory system, which is measured by P0.1. It has been shown to be a reliable predictor of successful weaning off of mechanical ventilation. The inspiration must be blocked for more than 100 msec in order to use the usual P0.1 measurement methods. Patients with liver cirrhosis have been found to have elevated P0.1 levels. Furthermore, a favourable correlation between P0.1 and FEV1/FVC has been demonstrated. Furthermore, a positive correlation between P0.1 and the MELD score has been seen, suggesting that these individuals have abnormally elevated respiratory drive".

Measurement of "maximal inspiratory pressure and maximal expiratory pressure

The non-invasive, straightforward, and useful measures of respiratory muscle strength at the mouth are maximum expiratory pressure (MEP) and maximal inspiratory pressure (MIP). It has been reported that patients with liver cirrhosis have altered MIP and MEP levels. The MELD score and the presence of ascites have been observed to strongly correlate with MIP and MEP values. In patients with liver cirrhosis, it has also been demonstrated that MIP and MEP values correspond with the score on the modified Medical Research Council Dyspnoea Scale. Furthermore, patients with alcohol-induced liver cirrhosis have been found to have lower MIP and MEP values than patients with hepatitis B and hepatitis C virus-induced liver cirrhosis. Notably, a prior study found that MIP was a prognostic measure of death in individuals with liver cirrhosis".

REVIEW OF RELATED STUDIES

Vaishnav, Bhumika et al (2024)[66] sought to assess each research participant's arterial blood gas (ABG) and pulmonary function test (PFT) in order to investigate the impact of liver impairment on the lungs. They came to the conclusion that the study participants' common findings included metabolic acidosis and poor FEV1/FVC and DLCO. Advanced hepatic cirrhosis was frequently associated with pulmonary impairment. Compared to patients without HPS, individuals with HPS showed worse ABG and PFT values.

Vignesh V et al (2023)[67] In this investigation, the degree of arterial hypoxaemia and pulmonary functions were compared to the severity of liver illness. They came to the conclusion that the degree of liver cirrhosis and lung functions are significantly correlated. PaO2 and SaO2 levels in ABG were considerably lower in individuals with Child-Pugh class C cirrhosis than in those with class A and B cirrhosis. Additionally, pulmonary function testing showed decreased FEV1 and FVC values in patients with Child-Pugh class C. Among patients with liver cirrhosis, restrictive lung disease was more prevalent than obstructive lung disease.

Nabil Farouk Awad, Abd-Allah Mohammad Elbalsha, Mohamed Zakria Abo Amer, and Mohamed Helmy Elsayed Ibrahim conducted a cross-sectional study on 50 patients at Al-Azhar University Hospitals between November 2018 and May 2019. Based on the Child Pugh Classification, they were split up into three categories (A, B, and C). All 50 patients in the study group had a 30% prevalence of hypoxia; patients with Child C and Child B had hypoxia (62% and 29.4%, respectively), while none of the patients with Child A had hypoxia. When compared to other groups, it was shown that patients in Child class C had the lowest lung functioning overall. However, when compared to patients in class A, those in child B also exhibited noticeably lower

pulmonary functioning.[68]

Alkhayat K et al (2017)[69] Our study's objective is to determine the extent of impaired pulmonary function in liver cirrhosis patients and how it relates to the Child-Pugh grading. They came to the conclusion that severe restrictive and obstructive ventilator defects at the level of both small and large airways are caused by anomalies in pulmonary function in patients with liver cirrhosis.

Irem et al (2008),[70] additionally investigated the connection between 39 individuals' lung function tests and liver cirrhosis. They discovered that 33.3% of patients had hypoxia and that patients with ascites had lower Pa O2 and Sa O2 levels than patients without ascites. The number of hypoxic patients in children B and C did not differ statistically significantly in their study.

Tüzün A et al (2001)[71] calculated spirometry using the single breath method, which included lung volumes, flow rates, and carbon monoxide diffusing capacity. Three groups of patients were created: all patients, patients with ascite, and patients without ascite. Comparing these groups to the control group, all cirrhotic and ascite patients had reduced FEV1/FVC, FEF25, and FEF25-75 values. In contrast, all cirrhotic individuals had normal FEV1/FVC. Although there was no difference between the patient and control group, 15.3% of cirrhotic patients had abnormalities. FEF75 was the most often impacted pulmonary function test, with aberrant results in 66.6% of patients. 46.1% of cirrhotic patients had hypoxaemia, although there was no difference between the groups. Additionally, patients with and without ascite did not differ from one another. In conclusion, our data indicate that FEF25-75 and FEF75, respectively, were the pulmonary function tests most impacted.

MATERIAL AND METHODS

- **Study design:** Hospital-based cross-sectional study
- **Study area:** Department of General Medicine, Shri B M Patil Medical College and Research Centre, Vijayapura, Karnataka, India.
- **Study period:** Research study was conducted from May 2023 to June 2024. Below is the work plan.

Table 2: Work plan of the study with percentage of allocation of study time and duration in months

Work plan	**% of allocation of study time**	**Duration in months**
Understanding the problem, preparation of questionnaire.	5-10%	May 2023
Pilot study, Validation of questionnaire, data collection and manipulation	Upto 80%	June 2023 to March 2024
Analysis and interpretation	5-10%	April 2024 to May 2024
Dissertation write-up and submission	5-10%	June 2024

- **Sample size**: As per the study done by Awad NF et.al.[66] pulmonary hypoxa were seen in at least 30% patients. By above considerations average prevalence of pulmonary hypoxia in each group can be considered as 4.4% .Considering the confidence limit of these studies to be 95% with 5% level of significance and margin of error 0.05.The sample size computed using the following formula

Sample size (n) = $(Z^2 * p*(1-p)) / d^2$

Where

Z is the z score = 2.17

d is the margin of error = 0.5

n is the population size = 65

p is the proportion of population =0.044

The estimated sample size of this study is **65**

- **Inclusion criteria:**

1. Patients who are clinically or radiologically (USG) confirmed cases of cirrhosis of liver who are aged more than 18 years irrespective of race and gender.

- **Exclusion criteria:**

1. Patients suffering from acute conditions such as sepsis, PTE, or ARDS.
2. Individuals with established lung disorders, such as COPD, bronchial asthma, old pulmonary Koch's, bronchiectasis, ILD, cancer, and/or heart disorders.
3. Patients who suffer from illnesses including morbid obesity, neuromuscular diseases, or significant deformities of the chest wall or vertebral column that could affect their pulmonary function tests or result in hypoxaemia.
4. Patients in poor general condition.

METHODOLOGY:

Study Design and Setting

This cross-sectional study was conducted at B.L.D.E (Deemed to be University) Shri B.M. Patil Medical College Hospital and Research Centre, Vijayapura, over an 18-month period from May 2023 to June 2024. The study focused on evaluating the relationship between liver cirrhosis severity and pulmonary function parameters in hospitalized patients.

Patient Selection and Recruitment

Patients admitted to the medical wards with diagnosed liver cirrhosis were

screened for eligibility based on predetermined inclusion and exclusion criteria. Patient enrollment followed a systematic sampling approach, with all eligible patients being invited to participate in the study after providing informed consent.

Data Collection Process

Initial patient assessment was conducted on the day of admission. A structured interview was performed using a standardized questionnaire designed specifically for the study. In cases where patients were unable to provide responses, information was obtained from accompanying family members or other reliable sources. The questionnaire was designed to capture comprehensive demographic and clinical information.

Demographic and Clinical Data:

Detailed demographic information was collected, including name, age, sex, religion, and socioeconomic status (assessed using the modified Kuppuswamy scale). Lifestyle factors such as dietary habits, occupational stress levels, and personal habits were documented. Particular attention was paid to documenting risk factors for liver disease, including:

- History of viral hepatitis
- Alcohol consumption patterns
- Presence of non-alcoholic steatohepatitis
- History of autoimmune disorders
- Cholestatic conditions
- Underlying metabolic disorders

Clinical Assessment:

A comprehensive clinical examination was performed on all participants, with particular attention to signs of liver disease and respiratory system involvement. The

severity of liver cirrhosis was assessed using standardized criteria. Physical findings related to both hepatic and pulmonary systems were documented systematically.

Laboratory Investigations:

A comprehensive panel of investigations was performed on all participants, including:

- Liver function tests to assess hepatic synthetic function and injury
- Viral markers (HIV, HCV, HBsAg) for etiological evaluation
- Prothrombin time for coagulation assessment
- Random blood sugar for metabolic evaluation

Imaging Studies:

Participants underwent multiple imaging studies including:

- Chest X-ray for evaluation of pulmonary pathology
- Abdominal ultrasonography to confirm cirrhosis and assess for complications
- Electrocardiography to evaluate cardiac status

Pulmonary Function Assessment:

Detailed pulmonary function evaluation was conducted through:

- Spirometry testing for ventilatory function assessment
- Arterial blood gas analysis for evaluation of gas exchange All pulmonary function tests were performed following standard protocols and quality control measures.

Quality Control Measures:

All investigations were performed in accredited laboratory facilities following standardized procedures. Spirometry testing was conducted by trained technicians following American Thoracic Society/European Respiratory Society guidelines. Regular calibration of equipment was ensured throughout the study period.

Data Management:

All collected data was recorded in individual case record forms and subsequently transferred to a secure electronic database. Regular data auditing was performed to ensure completeness and accuracy of entries. Patient confidentiality was maintained throughout the study period.

STATISTICAL ANALYSIS

SPSS version 21 was used to analyse the data after it was entered into an Excel sheet. The findings were displayed both graphically and tabularly. For quantitative data, the mean, median, standard deviation, and ranges were computed. Frequencies and percentages were used to express the qualitative data. Student t test (Two Tailed) was used to test the significance of mean and P value <0.05 was considered significant.

RESULTS

The present study was conducted in the department of General medicine at Shri B.M.Patil medical college, Hospital and research centre, Vijayapura from May 2023 to December 2024 to study relationship between severity of liver cirrhosis and pulmonary function tests. Total of 65 patients were included in the study.

Following were the results of the study:

Table 3 shows the demographic data comparison between the three study groups categorized by Child-Pugh classification. There was a statistically significant difference in age between the groups (p=0.019), with Group I (Child A) having the youngest patients (mean age 35.50 years), while Group II (Child B) had the oldest (mean age 46.52 years). Regarding gender distribution, males predominated in all groups, with Group II having one female patient, though this difference wasn't statistically significant (p=0.415).

Table 3: Comparison between studied groups according to demographic data

Variables	Group I (n=6)	Group II (n=21)	Group III (n=38)	P-value
Age (years)				
Mean	35.50	46.52	43.39	**0.019***
±SD	10.78	9.54	6.94	
Sex				
Males	6 (100%)	20 (95.2%)	38 (100%)	0.415
Females	0 (0%)	1 (4.8%)	0 (0%)	

*: p-value < 0.05 is considered significant.

Figure 9: Comparison between studied groups according to demographic data

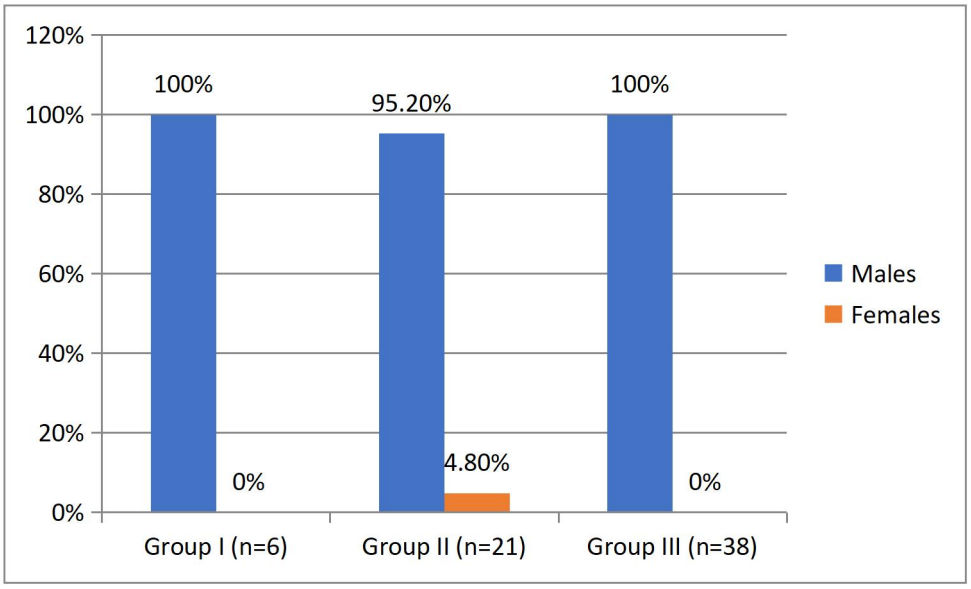


Table 4 shows the classification of studied patients according to Child-Pugh score. As expected, there was a highly significant difference between groups ($p<0.001$), with Group I having a mean score of 6.00, Group II having 8.29, and Group III having 11.03. This validates the proper stratification of patients into their respective Child-Pugh classes.

Table 4: Classification of studied patients according to Child-Pugh score

Variables	Group I (n=6)	Group II (n=21)	Group III (n=38)	p-value
Child score				
Mean	6.00	8.29	11.03	**< 0.001***
±SD	0.00	0.72	0.85	

*: p-value < 0.001 is considered highly significant.

Figure 10: Classification of studied patients according to Child-Pugh score

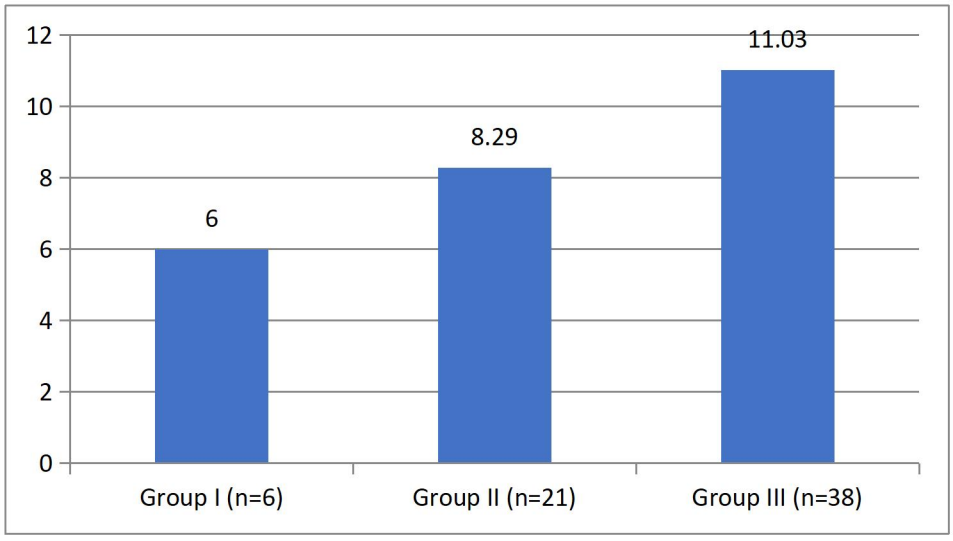


Table 5 shows the comparison between studied groups regarding MELD score. There was a highly significant difference between groups ($p<0.001$), with progressively higher MELD scores as Child-Pugh class worsened: Group I (10.67), Group II (13.76), and Group III (19.32). This demonstrates the correlation between these two liver disease severity classification systems.

Table 5: Comparison between studied groups according to MELD score

Variables	Group I (n=6)	Group II (n=21)	Group III (n=38)	P-value
MELD score				
Mean	10.67	13.76	19.32	**< 0.001***
±SD	2.25	4.98	4.45	

*: p-value < 0.001 is considered highly significant.

Figure 11: Comparison between studied groups according to MELD score

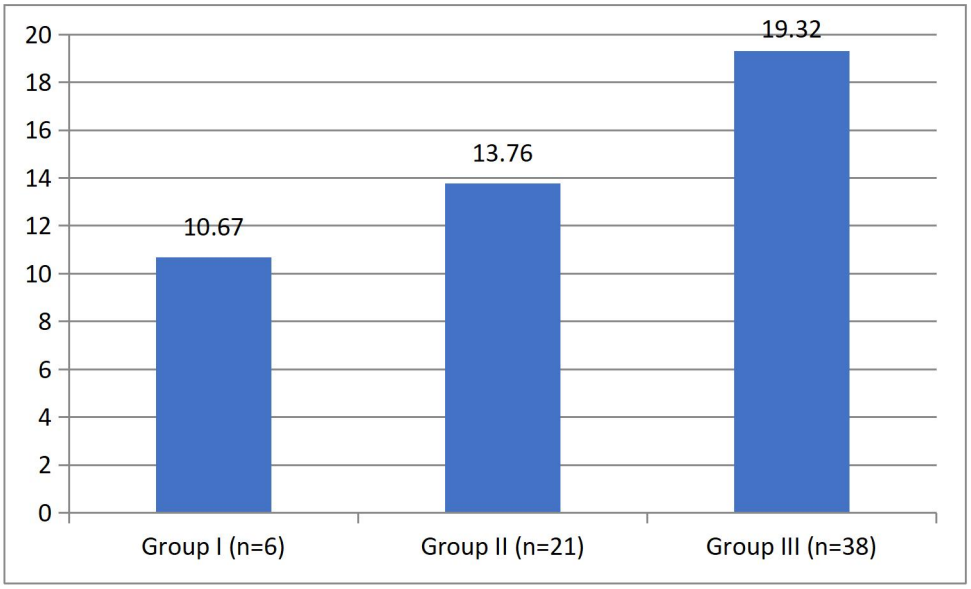


Table 6 shows the distribution of ascites among the study groups. There was a highly significant difference in ascites severity across groups ($p<0.001$). Most patients in Group I (83.3%) had no ascites, while none of the patients in Group III were free of ascites. Moderate ascites was most common in Group III (50%), and gross ascites was present in 39.5% of Group III patients but not in Group I. This demonstrates that ascites severity increases with worsening liver function.

Table 6: Comparison between studied groups according to ascites distribution

Variables	Group I (n=6)	Group II (n=21)	Group III (n=38)	P-value
Ascites				
None	5 (83.3%)	5 (23.8%)	0	**< 0.001***
Minimal	0(0%)	6 (28.6%)	1 (2.6%)	
Mild	1 (16.7%)	2 (9.5%)	3 (7.9%)	
Moderate	0(0%)	4 (19%)	19 (50%)	
Gross	0(0%)	4 (19%)	15 (39.5%)	

*: p-value < 0.01 is considered highly significant.

Figure 12: Comparison between studied groups according to ascites distribution

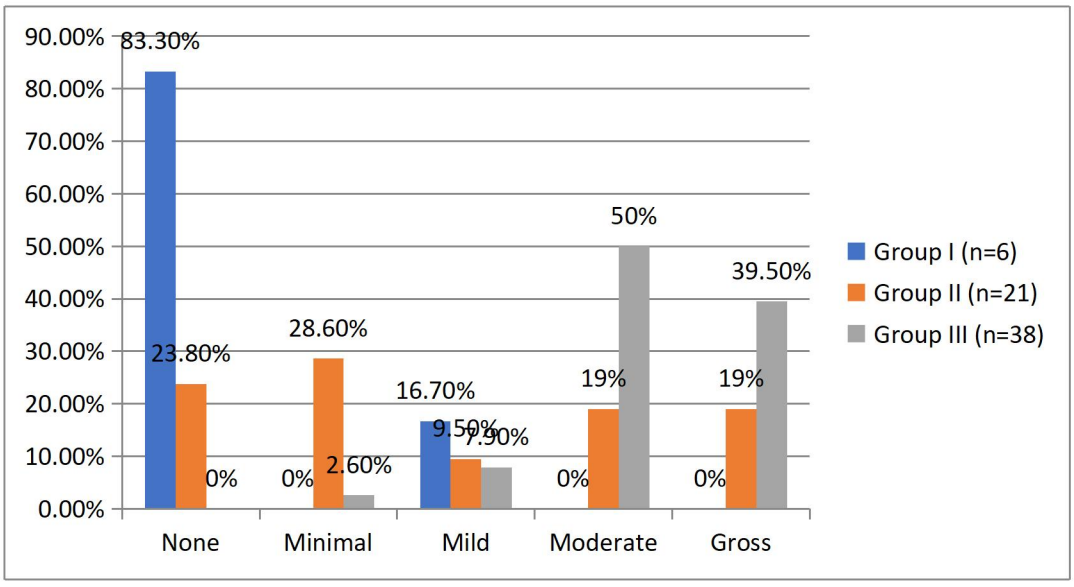


Table 7 shows the comparison of ultrasonographic findings between the study groups. Hepatomegaly showed a statistically significant difference (p=0.047) among groups, being most common in Group I (66.7%) and least common in Group II (19%). Splenomegaly and altered echo texture didn't show statistically significant differences between groups, though splenomegaly was more prevalent in Groups II and III.

Table 7: Comparison between studied groups according to USG findings

Variables	Group I (n=6)	Group II (n=21)	Group III (n=38)	P-value
Hepatomegaly	4 (66.7%)	4 (19%)	17 (44.7%)	**0.047**
Splenomegaly	2 (33.3%)	13 (61.9%)	23 (60.5%)	0.486
Altered Echo texture	2 (33.3%)	10 (47.6%)	11 (28.9%)	0.364

*: p-value < 0.01 is considered highly significant.

Figure 13: Comparison between studied groups according to USG findings

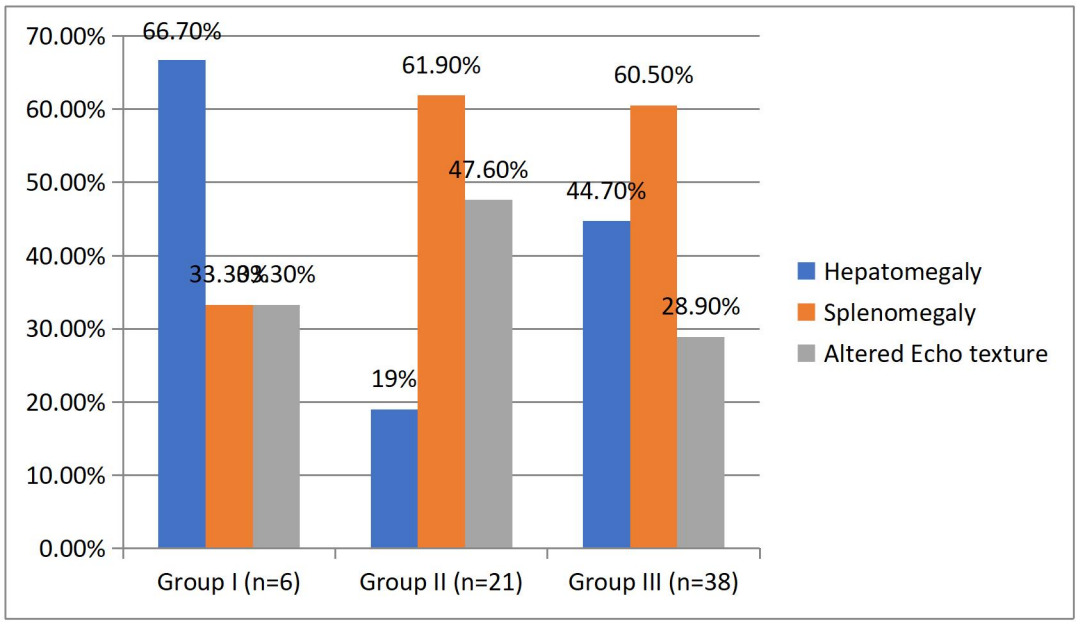


Table 8 shows the comparison between the three study groups (categorized by Child-Pugh classification) regarding arterial blood gas parameters. The table presents mean values and standard deviations for pH, PCO2, PO2, HCO3, and SO2 across all groups. Although there appears to be a trend toward lower pH values as liver disease severity increases (Group I: 7.57, Group II: 7.42, Group III: 7.39), this difference did not reach statistical significance (p=0.118). Similarly, PO2 values show a declining trend with increasing disease severity (Group I: 86.28 mmHg, Group II: 76.99 mmHg, Group III: 73.81 mmHg), though not statistically significant (p=0.353). PCO2 values were slightly lower in Group I (25.97 mmHg) compared to Groups II and III (28.25 and 28.44 mmHg respectively), suggesting a mild respiratory alkalosis pattern. Bicarbonate levels (HCO3) were comparable across all groups (approximately 20-21 mEq/L), indicating similar compensatory mechanisms. Oxygen saturation (SO2) showed minimal differences between groups. Overall, the data suggests that patients with cirrhosis tend to have subtle blood gas abnormalities that don't significantly differ based on Child-Pugh classification.

Table 8: Comparison between studied groups according to arterial blood gases

	Variables	**Group I (n=6)**	**Group II (n=21)**	**Group III (n=38)**	**P-value**
pH	Mean	7.57	7.42	7.39	0.118
	±SD	0.04	0.19	0.21	
PCO2 (mmHg)	Mean	25.97	28.25	28.44	0.564
	±SD	4.78	4.98	5.46	
PO2 (mmHg)	Mean	86.28	76.99	73.81	0.353
	±SD	8.91	18.64	21.54	

HCO3 (mEq/L)	Mean	21.03	20.31	20.44	0.907
	±SD	2.22	4.13	3.26	
SO2 (%)	Mean	94.93	90.64	90.51	0.602
	±SD	2.61	10.88	10.32	

Figure 14: Comparison between studied groups according to arterial blood gases

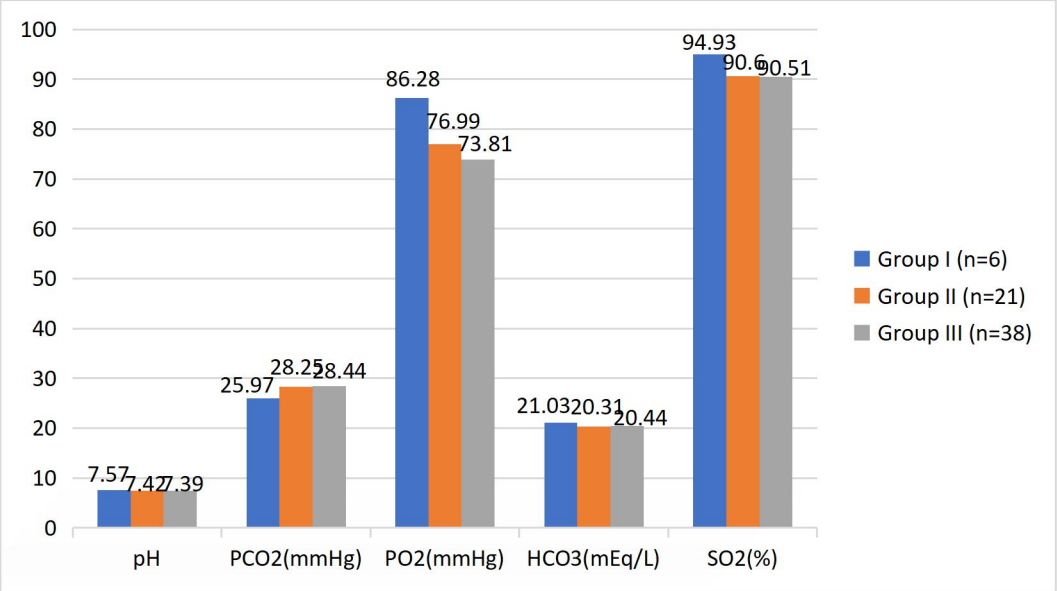


Table 9 shows the comparison of pulmonary function test parameters before and after bronchodilator administration across the three study groups. This table demonstrates statistically significant differences in several key parameters. Forced Vital Capacity (FVC) percentages showed a clear declining pattern with worsening liver function, both pre-bronchodilator (Group I: 76.17%, Group II: 68.21%, Group III: 58.81%, p=0.034) and post-bronchodilator (Group I: 78%, Group II: 70.4%, Group III: 59.71%, p=0.024). Similarly, Forced Expiratory Volume in 1 second (FEV1) percentages decreased significantly with increasing disease severity, both pre-bronchodilator (Group I: 80.5%, Group II: 67.7%, Group III: 59.9%, p=0.030) and post-bronchodilator (Group I: 83.3%, Group II: 70.8%, Group III: 60.6%, p=0.020). The FEV1/FVC ratio remained preserved across all groups without significant differences, suggesting that the predominant pattern is restrictive rather than obstructive. Forced Expiratory Flow at 25-75% of FVC (FEF 25-75%) showed borderline significance pre-bronchodilator (p=0.054) and reached statistical significance post-bronchodilator (p=0.042), with highest values in Group I. This data indicates that pulmonary function, particularly lung volumes, progressively deteriorates with increasing severity of liver disease, and this pattern persists even after bronchodilator administration.

Table 9: Comparison between studied groups according to pulmonary function tests

Variables		Group I (n=6)	Group II (n=21)	Group III (n=38)	P-value
FVC (%)	Pre	76.17±27.4	68.21±15.88	58.81±12.8	**0.034***
	Post	78±26.8	70.4±16.7	59.71±13.5	**0.024***
FEV1 (%)	Pre	80.5±28.9	67.7±16.3	59.9±13.99	**0.030***
	Post	83.3±28.5	70.8±18.03	60.6±15.7	**0.020***

FEV1/FVC (%)	Pre	106±8.6	101.8±9.8	99.3±8.3	0.190
	Post	106.5±9.3	101.2±8.9	101.5±12.3	0.489
FEF 25-75% (%)	Pre	89.33±32.99	63.14±23.1	65.4±22.2	0.054
	Post	95.8±34.9	73.9±25.4	64.8±25.3	**0.042***

*: p-value < 0.05 is considered significant.

Figure 15a: Comparison between studied groups according to pre-pulmonary function tests

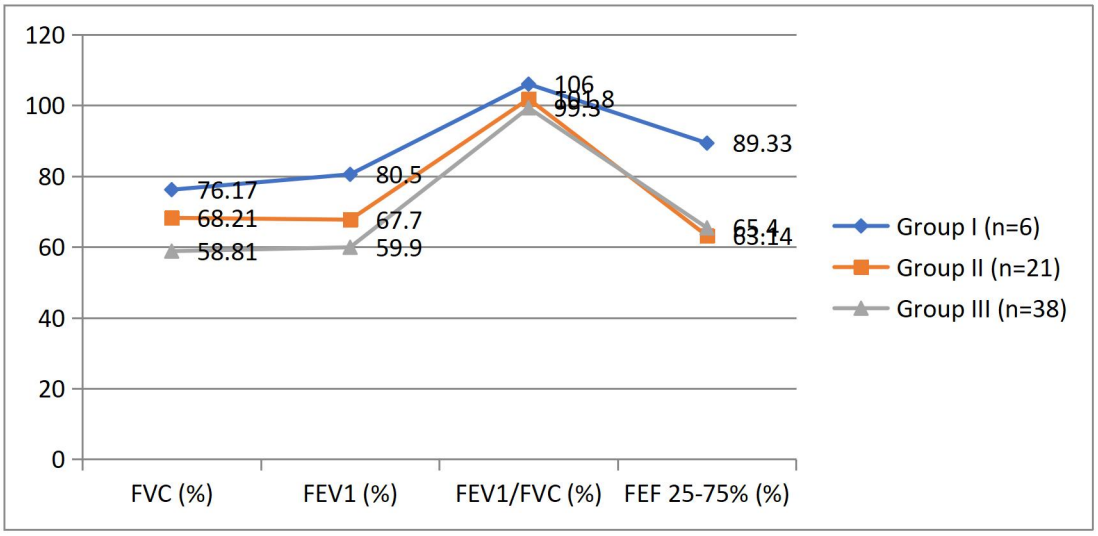


Figure 15b: Comparison between studied groups according to post-pulmonary function tests

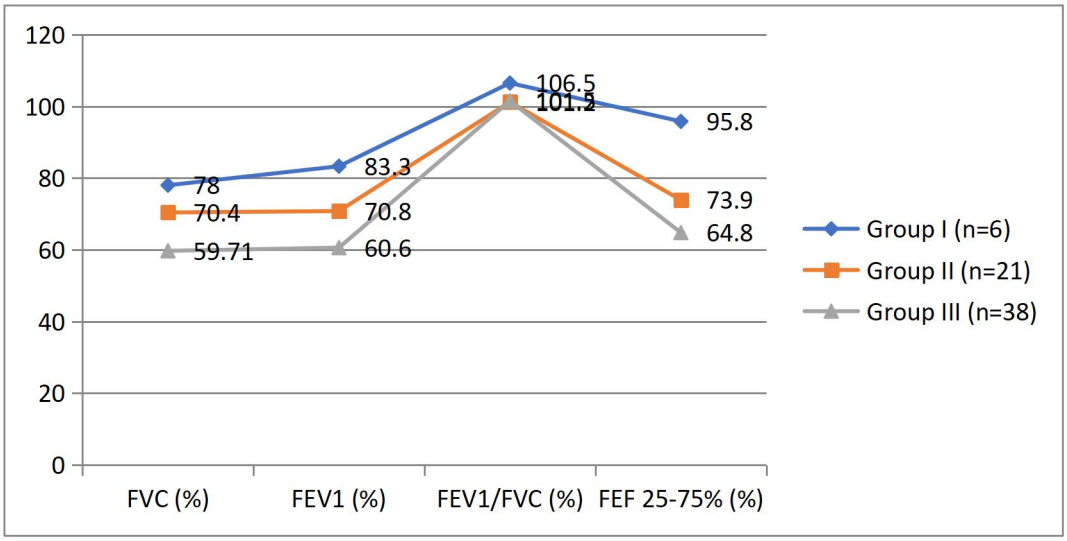


Table 10 shows the distribution of ventilatory patterns among the studied groups. There was a clear pattern: normal spirometry was most common in Group I (66.7%) and Groups II (52.4%) and while restrictive pattern dominated in group III (94.7%) and only one patient had obstructive pattern and belonged to group III (2.6%). This difference was statistically significant (p<0.001)

Table 10: Distribution of ventilatory patterns among studied groups

Variables	Group I (n=6)	Group II (n=21)	Group III (n=38)	P-value
Normal Spirometry	4 (66.7%)	11 (52.4%)	1 (2.6%)	**<0.001***
Restrictive Pattern	2 (33.3%)	10 (47.6%)	36 (94.7%)	
Obstructive Pattern	0 (0.0%)	0 (0.0%)	1 (2.6%)	

*Chi-square test

Figure 16: Distribution of ventilatory patterns among studied groups

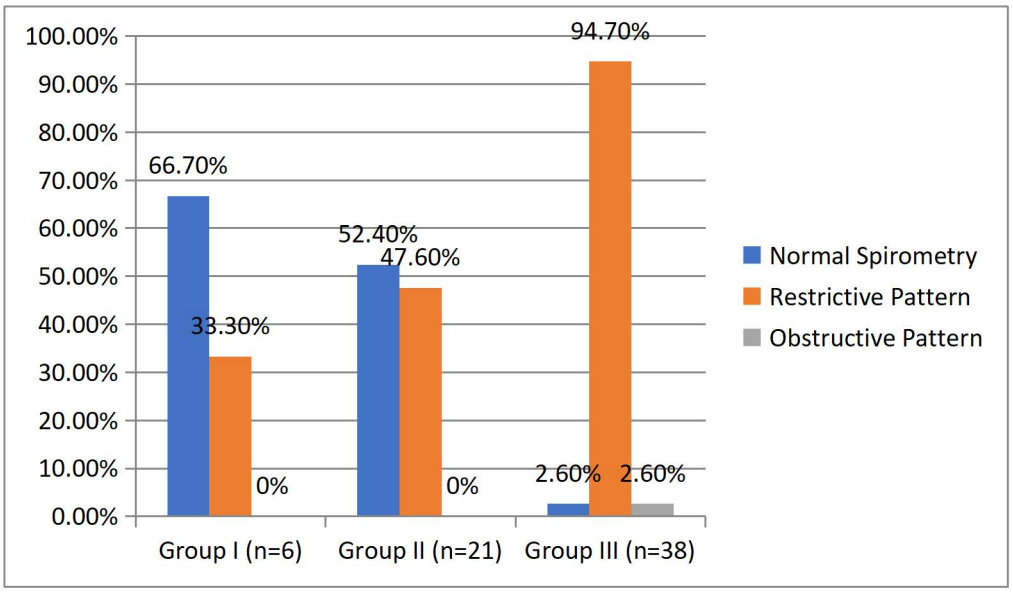


Table 11 shows the prevalence of hypoxia (PO2 < 80 mmHg) among the studied groups. Although the differences weren't statistically significant (p=0.807), there was a trend toward increasing hypoxia prevalence with worsening liver function: Group I (33.3%), Group II (38.1%), and Group III (44.7%).

Table 11: Prevalence of hypoxia (PO2 < 80 mmHg) among studied groups

Variables	Group I (n=6)	Group II (n=21)	Group III (n=38)	P-value
No Hypoxia	4 (66.7%)	13 (61.9%)	21 (55.3%)	0.807
Hypoxia	2 (33.3%)	8 (38.1%)	17 (44.7%)	

Figure 17: Prevalence of hypoxia (PO2 < 80 mmHg) among studied groups

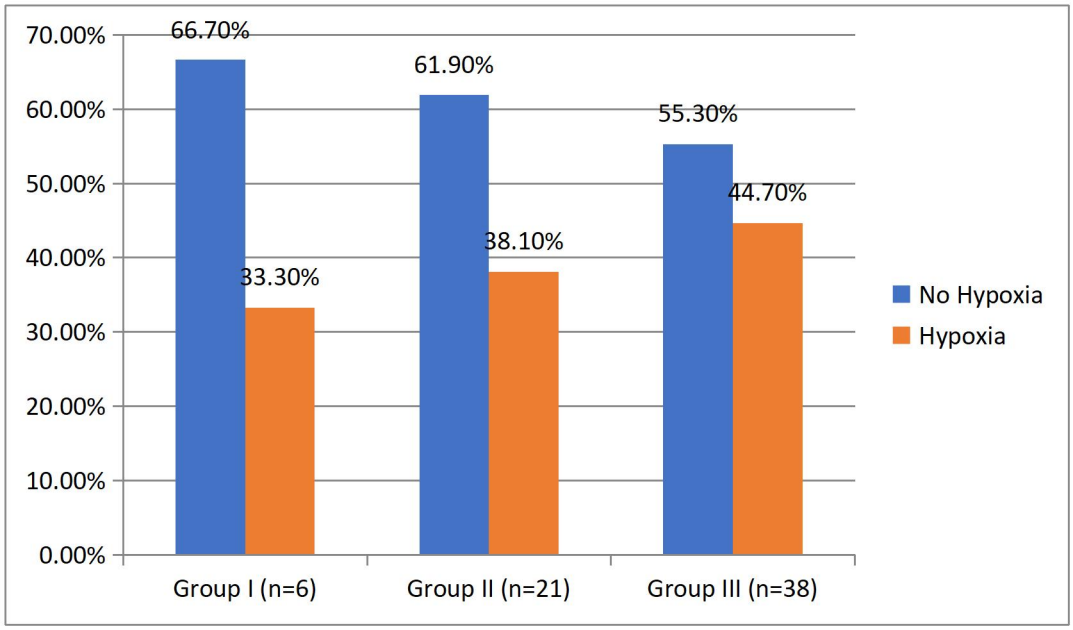


Table 12 shows correlations between Child-Pugh score and pre-bronchodilator pulmonary function parameters. We found statistically significant negative correlation for FVC, FEV1 and FEF 25-75% ($p<0.001$). Other parameters didn't reach statistical significance (FEV1/FVC, pH, PCO2, HCO3, PO2 and SO2).

Table 12: Correlation between Child-Pugh score and pre- pulmonary function parameters in all patients

Variables	Correlation coefficient (r)	p-value
Child score vs. FVC	-0.505	**<0.001**
Child score vs. FEV1	-0.528	**<0.001**
Child score vs. FEV1/FVC	0.007	0.954
Child score vs. FEF 25-75%	-0.440	**<0.001**
Child score vs. pH	-0.055	0.664
Child score vs. PCO2	0.080	0.528
Child score vs. HCO3	-0.043	0.733
Child score vs. PO2	-0.156	0.215
Child score vs. SO2	-0.047	0.711

*: p-value < 0.01 is considered highly significant.

Table 13 shows correlations between Child-Pugh score and post-bronchodilator pulmonary function parameters. We found statistically significant negative correlation for FVC, FEV1 and FEF 25-75% ($p<0.001$) FEV1/FVC correlation did not reach statistical significance, though weak negative correlations was observed.

Table 13: Correlation between Child-Pugh score and post- pulmonary function parameters in all patients

Variables	Correlation coefficient (r)	p-value
Child score vs. FVC	-0.482	**<0.001**
Child score vs. FEV1	-0.521	**<0.001**
Child score vs. FEV1/FVC	-0.030	0.814
Child score vs. FEF 25-75%	-0.442	**<0.001**

*: p-value < 0.05 is considered significant.

Table 12 shows correlations between MELD score and pre-bronchodilator pulmonary function parameters. There was a significant negative correlation between MELD score and FVC (r=-0.312, p=0.011) and FEV1 (r=-0.290, p=0.019). Other parameters showed weak correlations that didn't reach statistical significance.

Table 14: Correlation between MELD score and pre- pulmonary function parameters in all patients

Variables	Correlation coefficient (r)	p-value
MELD score vs. FVC	-0.312	**0.011**
MELD score vs. FEV1	-0.290	**0.019**
MELD score vs. FEV1/FVC	0.073	0.563
MELD score vs. FEF 25-75%	-0.151	0.229
MELD score vs. pH	-0.161	0.202
MELD score vs. PCO2	-0.041	0.748
MELD score vs. HCO3	-0.179	0.155
MELD score vs. PO2	-0.142	0.258
MELD score vs. SO2	-0.159	0.207

*: p-value < 0.05 is considered significant.

Table 15 shows correlations between MELD score and post-bronchodilator pulmonary function parameters. Only FVC and MELD correlations reached statistical significance (p=0.021), though most parameters (FEV1 and FEF 25-75%) showed very weak correlations in various directions.

Table 15: Correlation between MELD score and post- pulmonary function parameters in all patients

Variables	Correlation coefficient (r)	p-value
MELD score vs. FVC	-0.285	**0.021**
MELD score vs. FEV1	-0.263	0.035
MELD score vs. FEV1/FVC	0.076	0.545
MELD score vs. FEF 25-75%	-0.138	0.273

DISCUSSION

In our study population, there was a significant age difference between the three Child-Pugh groups ($p=0.019$), with Child A patients being the youngest (mean age 35.50 years) and Child B patients being the oldest (mean age 46.52 years). This finding differs somewhat from studies by Krowka et al., who reported a more linear relationship between age and cirrhosis severity, with progressively increasing age corresponding to worsening Child-Pugh class.[72] The predominance of male patients in our study (100% in Child A, 95.2% in Child B, and 100% in Child C) is consistent with the epidemiological pattern of liver cirrhosis observed globally, as reported by Mokdad et al., who found that cirrhosis affects men disproportionately in most populations worldwide.[73]

The significant differences in Child-Pugh scores ($p<0.001$) and MELD scores ($p<0.001$) across the three groups validate our stratification methodology and confirm the expected pattern of increasing disease severity. A notable finding in our study was the distribution of ascites, showing a highly significant difference across the three groups ($p<0.001$), with 83.3% of Child A patients having no ascites, while all Child C patients demonstrated some degree of ascites. This aligns with the findings of Møller et al., who demonstrated that ascites development correlates strongly with deteriorating liver function and represents a critical decompensation event in cirrhosis.[74]

Ultrasonographic Findings

Our study demonstrated a significant difference in hepatomegaly prevalence among the three groups ($p=0.047$), with the highest prevalence in Child A patients (66.7%) and lowest in Child B patients (19%). This finding contrasts with the traditional understanding that hepatomegaly typically precedes hepatic atrophy in advanced cirrhosis, as described by D'Amico et al.[75] The lack of significant differences in

splenomegaly and altered echo texture across groups suggests that these parameters may be less sensitive to changes in disease severity or may develop earlier in the disease course.

Arterial Blood Gas Analysis

The arterial blood gas parameters in our study showed a trend toward decreasing pH values with increasing severity of liver disease (Child A: 7.57, Child B: 7.42, Child C: 7.39), although this did not reach statistical significance (p=0.118). Similarly, PO2 values demonstrated a declining trend with increasing disease severity (Child A: 86.28 mmHg, Child B: 76.99 mmHg, Child C: 73.81 mmHg), though not statistically significant (p=0.353). These trends are consistent with findings by Melot et al., who reported a progressive decrease in arterial oxygenation with worsening liver function in cirrhotic patients.[76]

The correlation analysis did not show significant correlations between Child-Pugh score and arterial blood gas parameters including pH, PCO2, HCO3, PO2, and SO2. Similarly, we found no significant correlations between MELD score and these parameters. This differs from studies by Lustik et al., who described metabolic acid-base disturbances in advanced cirrhosis due to impaired lactate clearance and renal dysfunction..[77] Contrast to this, the study by Funk et al., demonstrated that acid-base derangements correlate with MELD score and can predict mortality in cirrhotic patients.[78] This discrepancy might be due to variations in patient populations or compensatory mechanisms present in our cohort.

The prevalence of hypoxia (PO2 < 80 mmHg) showed an increasing trend with worsening liver function (Child A: 33.3%, Child B: 38.1%, Child C: 44.7%), though this did not reach statistical significance (p=0.807). This pattern aligns with observations by Rodríguez-Roisin et al., who described a spectrum of oxygenation

abnormalities in cirrhosis ranging from mild hypoxemia to severe hepatopulmonary syndrome.[79]

Pulmonary Function Tests

One of the most significant findings in our study was the progressive deterioration of pulmonary function parameters with increasing severity of liver disease. Forced Vital Capacity (FVC) percentages showed a clear declining pattern with worsening liver function, both pre-bronchodilator (Child A: 76.17%, Child B: 68.21%, Child C: 58.81%, p=0.034) and post-bronchodilator (Child A: 78%, Child B: 70.4%, Child C: 59.71%, p=0.024). Similarly, Forced Expiratory Volume in 1 second (FEV1) percentages decreased significantly with increasing disease severity, both pre-bronchodilator (Child A: 80.5%, Child B: 67.7%, Child C: 59.9%, p=0.030) and post-bronchodilator (Child A: 83.3%, Child B: 70.8%, Child C: 60.6%, p=0.020).

These findings are in accordance with the study by Krowka and Cortese, who reported reduced vital capacity and total lung capacity in cirrhotic patients compared to controls.[80] Similarly, Hourani et al. demonstrated reduced FVC and FEV1 in cirrhotic patients, with more pronounced reductions in those with more advanced disease.[81] The mechanisms underlying these changes may include restricted diaphragmatic movement due to ascites, pleural effusions, muscle wasting, and respiratory muscle weakness secondary to malnutrition and electrolyte disturbances.

Interestingly, the FEV1/FVC ratio remained preserved across all groups without significant differences (Child A: 106%, Child B: 101.8%, Child C: 99.3%, p=0.190 pre-bronchodilator; Child A: 106.5%, Child B: 101.2%, Child C: 101.5%, p=0.489 post-bronchodilator). This finding suggests that the predominant pattern of pulmonary dysfunction in our patients was restrictive rather than obstructive, which is consistent with the study by Duranti et al., who reported a high prevalence of restrictive patterns in

cirrhotic patients.[82]

Our analysis of ventilatory patterns revealed a striking predominance of restrictive pattern in Child C patients (94.7%) compared to Child A (33.3%) and Child B (47.6%), with this difference being statistically significant ($p<0.001$). This finding is consistent with several previous studies that have identified restrictive patterns as the predominant abnormality in cirrhosis. The high prevalence of restrictive pattern in our Child C patients can be attributed to several factors: ascites limiting diaphragmatic excursion, pleural effusions, muscle wasting affecting respiratory muscles, and potentially increased chest wall stiffness due to fluid retention and inflammation. This aligns with observations by Yigit et al., who described the mechanistic basis for restrictive lung disease in advanced cirrhosis.[83]

The Forced Expiratory Flow at 25-75% of FVC (FEF 25-75%) showed borderline significance pre-bronchodilator ($p=0.054$) and reached statistical significance post-bronchodilator ($p=0.042$), with highest values in Child A patients. This parameter, which reflects small airway function, further supports the pattern of progressive pulmonary impairment with worsening liver disease.

Correlation between Liver Disease Severity and Pulmonary Function

A key finding in our study was the significant negative correlation between Child-Pugh score and multiple pulmonary function parameters. We found statistically significant negative correlations for FVC ($r=-0.505$, $p<0.001$), FEV1 ($r=-0.528$, $p<0.001$), and FEF 25-75% ($r=-0.440$, $p<0.001$) in pre-bronchodilator measurements. Similarly, post-bronchodilator measurements showed significant negative correlations for FVC ($r=-0.482$, $p<0.001$), FEV1 ($r=-0.521$, $p<0.001$), and FEF 25-75% ($r=-0.442$, $p<0.001$). These findings strongly suggest that pulmonary function deteriorates in parallel with worsening liver function, with moderate strength correlations indicating a

substantial relationship.

The MELD score showed weaker but still significant negative correlations with FVC (r=-0.312, p=0.011) and FEV1 (r=-0.290, p=0.019) in pre-bronchodilator measurements, and with FVC (r=-0.285, p=0.021) in post-bronchodilator measurements. The stronger correlations with Child-Pugh score compared to MELD score suggest that the Child-Pugh classification, which incorporates clinical parameters like ascites that directly affect pulmonary mechanics, may be more relevant for predicting pulmonary dysfunction than the MELD score, which is primarily based on laboratory parameters.

These findings are consistent with the study by Machicao et al., who found similar correlations between liver disease severity and pulmonary function abnormalities.[84]The strength of our correlations underscores the close relationship between hepatic dysfunction and pulmonary impairment in cirrhosis.

Clinical Implications

The findings of our study have several important clinical implications. The progressive deterioration of pulmonary function with worsening liver function underscores the need for regular pulmonary assessment in cirrhotic patients, particularly those with advanced disease. The high prevalence of restrictive pattern in Child C patients suggests that interventions aimed at improving lung volumes, such as ascites drainage when indicated, might be beneficial in selected patients with advanced cirrhosis.

The significant correlations between liver disease severity scores and pulmonary function parameters highlight the potential utility of these scores in identifying patients at risk for pulmonary complications. Regular monitoring of pulmonary function in patients with high Child-Pugh scores might allow early intervention and potentially improve outcomes.

The trend toward increasing hypoxia prevalence with worsening liver function, although not statistically significant in our study, warrants attention. Hypoxemia can exacerbate hepatic encephalopathy and contribute to multi-organ dysfunction in cirrhosis. Oxygen supplementation should be considered in hypoxemic cirrhotic patients, as suggested by Arguedas et al.[86]

Pathophysiological Considerations

The pathophysiological mechanisms underlying pulmonary dysfunction in cirrhosis are complex and multifactorial. The predominance of restrictive abnormalities in our patients, particularly in advanced disease, can be attributed to several factors. Ascites, which was universally present in our Child C patients, can elevate the diaphragm and restrict its movement, reducing lung volumes. Pleural effusions, which often accompany ascites in advanced cirrhosis, can further compromise lung expansion. Malnutrition and muscle wasting, common in advanced cirrhosis, can affect respiratory muscle strength and endurance, contributing to reduced inspiratory capacity.

Furthermore, systemic inflammation, which is increasingly recognized as a key component of advanced cirrhosis, can affect lung parenchyma and lead to interstitial changes that contribute to restrictive physiology. Elevated levels of inflammatory cytokines in cirrhosis may alter lung mechanics and gas exchange properties, as described by Fallon and Abrams.[88]

The gas exchange abnormalities observed in cirrhosis, including hypoxemia, are often attributed to ventilation-perfusion mismatch, intrapulmonary vascular dilatations, and diffusion limitation. The intrapulmonary vascular dilatations allow desaturated mixed venous blood to pass rapidly through the pulmonary circulation without adequate oxygenation, leading to a right-to-left shunt and arterial hypoxemia, as described by Rodríguez-Roisin and Krowka.[79]

Comparison with Similar Studies

Our findings both align with and diverge from existing literature in several aspects. The progressive decline in FVC and FEV1 with worsening liver function is consistent with most previous studies. For instance, Vachiéry et al. reported similar findings in their cohort of cirrhotic patients, with FVC and FEV1 decreasing progressively from Child A to Child C [80] which is similar to our study.

The strength of correlation between Child-Pugh score and pulmonary function parameters in our study is similar to that reported by Peng J et al.[87] However, we found relatively weaker correlations between MELD score and pulmonary function parameters, which differs from some studies that have reported stronger correlations. This difference may be attributed to variations in study populations, methodologies, or the complex, multifactorial nature of pulmonary dysfunction in cirrhosis.

Regarding arterial blood gases, our finding of decreasing PO2 with worsening liver function aligns with most previous studies. For example, Krowka et al. demonstrated a similar trend in their cohort of cirrhotic patients.[81] However, we did not find significant correlations between liver disease severity and arterial blood gas parameters, which contrasts with some previous studies.

The relationship between ascites and pulmonary function has been more consistently reported. Our finding of increasing ascites severity with worsening liver function and concurrent deterioration of pulmonary function parameters aligns with the study by Chao et al., who demonstrated significant improvements in pulmonary function following large-volume paracentesis in cirrhotic patients with tense ascites.[82]

Limitations and Future Directions

Our study has several limitations that warrant consideration. The relatively small

sample size, particularly in the Child A group (n=6), may have limited our ability to detect statistically significant differences or correlations. The cross-sectional design precludes establishing causality or temporal relationships between liver disease progression and pulmonary function changes.

We did not assess smoking history in detail, which could be a significant confounder, particularly for the obstructive pattern observed. Future studies should control for smoking and other potential confounders like occupational exposures and concomitant respiratory diseases.

The study did not include specific investigations for hepatopulmonary syndrome or portopulmonary hypertension, such as contrast echocardiography or right heart catheterization. These conditions can significantly impact pulmonary function and may have influenced our results.

Future research should focus on longitudinal studies to track changes in pulmonary function with progression of liver disease. Intervention studies evaluating the impact of treatments like paracentesis, bronchodilators, or liver transplantation on pulmonary function would provide valuable insights. Mechanistic studies exploring the pathophysiological links between liver dysfunction and pulmonary abnormalities, particularly at the molecular and cellular levels, would enhance our understanding of these complex relationships.

Conclusion

Our study demonstrates that pulmonary function, particularly FVC and FEV1, progressively deteriorates with increasing severity of liver cirrhosis. Restrictive pattern was the predominant abnormality in advanced cirrhosis (Child C), consistent with the traditional understanding of pulmonary dysfunction in cirrhosis. We found significant negative correlations between Child-Pugh score and multiple pulmonary

function parameters, with weaker but still significant correlations for MELD score, suggesting complex relationships between liver dysfunction and pulmonary abnormalities.

These findings highlight the importance of regular pulmonary assessment in cirrhotic patients and suggest potential therapeutic targets. Early recognition and management of pulmonary complications may improve quality of life and outcomes in this vulnerable patient population. Future research should focus on elucidating the mechanisms underlying these relationships and evaluating targeted interventions to address pulmonary dysfunction in cirrhosis.

CONCLUSION

- This study provides substantial evidence that pulmonary function deteriorates progressively with increasing severity of liver cirrhosis. Our findings demonstrated a significant decline in key pulmonary function parameters, particularly FVC and FEV1, as liver function worsened across Child-Pugh classes. This decline persisted even after bronchodilator administration, suggesting an underlying structural rather than reversible functional impairment.
- We observed a clear predominance of restrictive ventilatory pattern in patients with advanced cirrhosis (Child C), consistent with the traditionally reported pattern in cirrhosis literature. This finding supports the understanding that the pathophysiological mechanisms affecting pulmonary function in cirrhosis primarily involve mechanical factors like ascites, muscle wasting, and potentially parenchymal changes that limit lung expansion and reduce lung volumes.
- The significant negative correlations between Child-Pugh score and multiple pulmonary function parameters (FVC, FEV1, and FEF 25-75%) provide strong evidence for the relationship between liver disease severity and pulmonary dysfunction. These correlations were stronger than those observed with MELD score, suggesting that the clinical parameters incorporated in the Child-Pugh classification may be more relevant for predicting pulmonary impairment than the laboratory values that dominate the MELD score.

- The increasing prevalence of hypoxia with worsening liver function, though not reaching statistical significance in our study, aligns with the concept of a hepatopulmonary syndrome spectrum and emphasizes the importance of oxygenation assessment in cirrhotic patients. These findings highlight the need for routine pulmonary function assessment in cirrhotic patients, particularly those with advanced disease, to identify abnormalities early and potentially implement interventions to improve respiratory function and overall outcomes.
- In conclusion, our study demonstrates that severity of liver cirrhosis correlates with deterioration in pulmonary function, predominantly manifesting as a restrictive pattern in advanced disease. This understanding may guide clinicians in the comprehensive management of cirrhotic patients, emphasizing the importance of addressing pulmonary complications as part of the multisystem approach to this complex disorder.

SUMMARY

Our study evaluated the relationship between severity of liver cirrhosis and pulmonary function tests in 65 patients categorized according to Child-Pugh classification into Child A (n=6), Child B (n=21), and Child C (n=38).Pulmonary function tests revealed a significant decline in FVC percentages with worsening liver function, both pre-bronchodilator (Child A: 76.17%, Child B: 68.21%, Child C: 58.81%, p=0.034) and post-bronchodilator (Child A: 78%, Child B: 70.4%, Child C: 59.71%, p=0.024). Similarly, FEV1 percentages decreased significantly with increasing disease severity, both pre-bronchodilator (Child A: 80.5%, Child B: 67.7%, Child C: 59.9%, p=0.030) and post-bronchodilator (Child A: 83.3%, Child B: 70.8%, Child C: 60.6%, p=0.020). The FEV1/FVC ratio remained preserved across all groups. Analysis of ventilatory patterns revealed a predominance of restrictive pattern in Child C patients (94.7%) compared to Child A (33.3%) and Child B (47.6%) ($p<0.001$), which is consistent with the mechanical limitations caused by ascites and other factors in advanced cirrhosis. Arterial blood gas parameters showed a trend toward decreasing pH and PO2 values with increasing severity of liver disease. The prevalence of hypoxia (PO2 < 80 mmHg) showed an increasing trend with worsening liver function (Child A: 33.3%, Child B: 38.1%, Child C: 44.7%).Overall, our results demonstrate that pulmonary function deteriorates progressively with increasing severity of liver cirrhosis, with a predominance of restrictive pattern in advanced disease and significant correlations between liver disease severity scores and pulmonary function parameters.These findings highlight the importance of routine pulmonary function assessment in cirrhotic patients, particularly those with advanced disease, to identify abnormalities early and implement appropriate interventions.

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ANNEXURE I

Azadi Ka Amrit Mahotsav

BLDE
(DEEMED TO BE UNIVERSITY)
Declared as Deemed to be University u/s 3 of UGC Act, 1956
Accredited with 'A' Grade by NAAC (Cycle-2)
The Constituent College
SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA

BLDE (DU)/IEC/ 907/2023-24 10/4/2023

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this University met on **Saturday, 18th March, 2023 at 11.30 a.m. in the CAL Laboratory, Dept. of Pharmacology,** scrutinizes the Synopsis/ Research Projects of Post Graduate Student / Under Graduate Student /Faculty members of this University /Ph.D. Student College from ethical clearance point of view. After scrutiny, the following original/ corrected and revised version synopsis of the thesis/ research projects has been accorded ethical clearance.

TITLE: "A STUDY ON RELATIONSHIP BETWEEN SEVERITY OF LIVER CIRRHOSIS AND PULMONARY FUNCTION TESTS".

NAME OF THE STUDENT/PRINCIPAL INVESTIGATOR: DR.NIVEDITHA R.

NAME OF THE GUIDE: DR.R.M.HONNUTAGI, PROFESSOR, DEPT. OF GENERAL MEDICINE.

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Dr. Santoshkumar Jeevangi
Chairperson
IEC, BLDE (DU),
VIJAYAPURA

Chairman,
Institutional Ethical Committee,
BLDE (Deemed to be University)
Vijayapura

Dr.Akram A. Naikwadi
Member Secretary
IEC, BLDE (DU),
VIJAYAPURA

MEMBER SECRETARY
Institutional Ethics Committee
BLDE (Deemed to be University)
Vijayapura-586103. Karnataka

Following documents were placed before Ethical Committee for Scrutinization.

- Copy of Synopsis/Research Projects
- Copy of inform consent form
- Any other relevant document

Smt. Bangaramma Sajjan Campus. B. M. Patil Road (Sholapur Road). Vijayapura - 586103. Karnataka. India.
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College: Phone: +918352-262770. Fax: +918352-263019. E-mail: bmpmc.principal@bldedu.ac.in

ANNEXURE II

CONSENT FORM

BLDEDU'S SHRI B. M. PATIL MEDICAL COLLEGEHOSPITAL AND RESEARCH CENTRE, VIJAYAPURA- 586103

TITLE OF THE PROJECT - **"A STUDY ON RELATIONSHIP BETWEEN SEVERITY OF LIVER CIRRHOSIS AND PULMONARY FUNCTION TESTS"**

PRINCIPAL INVESTIGATOR - **Dr. NIVEDITHA R**

+91 9620810320

P.G. GUIDE NAME - **Dr. R. M. HONNUTAGI**

PROFFESSOR

DEPARTMENT OF MEDICINE

All aspects of this consent form are explained to the patient in the language understood by him/her.

INFORMED PART PURPOSE OF RESEARCH:

I have been informed about this study. I have also been given a free choice of participation in this study.

PROCEDURE:

I am aware that in addition to routine care received I will be asked series of questions by the investigator. I have been asked to undergo the necessary investigations and treatment, which will help the investigator inthis study.

RISK AND DISCOMFORTS:

I understand that I may experience some pain and discomfort during the examination or during my treatment. This is mainly the result of my condition and the

procedure of this study is not expected toexaggerate these feelings that are associated with the usual course of treatment.

BENEFITS:

I understand that my participation in this study will help to patient's survival and better outcome.

CONFIDENTIALITY:

I understand that the medical information produced by this study will become a part of Hospital records and will be subject to the confidentiality and privacy regulation. Information of a sensitive personal nature will not be a part of the medical records, but will be stored in the investigator's research file and identified only by code number. The code-key connecting name to numbers will be kept in a separate location.

If the data are used for publication in the medical literature or for teaching purpose, no name will be used and other identifiers such as photographs and audio or videotapes will be used only with my special written permission. I understand that I may see the photographs and videotapes and hear the audiotapes before giving this permission.

REQUEST FOR MORE INFORMATION:

I understand that I may ask more questions about the study at any time. **Dr. NIVEDITHA.R** is available to answer my questions or concerns. I understand that I will be informed of any significant new findings discovered during the course of the study, which might influence my continued participation.

If during the study, or later, I wish to discuss my participation in or concerns regarding this study with a person not directly involved, I am aware that the social worker of the hospital is available to talk with me.A copy of this consent form will be

given to me to keep for careful reading.

REFUSAL OR WITHDRAWAL OF PARTICIPATION:

I understand that my participation is voluntary and that I may refuse to participate or may withdraw consentand discontinue participation in the study at any time without prejudice to my present or future care at this hospital. I also understand that Dr. NIVEDITHA.R may terminate my participation in the study after he has explained the reasons for doing so and has helped arrange for my continued care by my own physician or physical therapist, if this is appropriate

INJURY STATEMENT:

I understand that in the unlikely event of injury to me resulting directly from my participation in this study, if such injury were reported promptly, the appropriate treatment would be available to me, but no further compensation would be provided. I understand that by my agreement to participate in this study I am not waiving any of my legal rights.

I have explained to the purpose of the research, the procedures required and the possible risks and benefitsto the best of my ability in patient's own language.

_____ _____

Dr. NIVEDITHA R Date

(Investigator)

STUDY SUBJECT CONSENT STATEMENT:

I confirm that **Dr. NIVEDITHA.R** has explained to me the purpose of research, the study procedures that I will undergo, and the possible risks and discomforts as well as benefits that I may experience in my own language. I have read and I understand this consent form. Therefore, I agree to give consent to participate as a subject in this research project.

_____ _____

Participant / Guardian Date

_____ _____

Witness to signature Date

ANNEXURE III

PER ABDOMEN CASE PROFORMA

Informant:

NAME: CASE NO:

AGE: IP NO:

SEX: DOA:

RELIGION: DOD:

CHIEF COMPLAINTS:

HISTORY OF PRESENT ILLNESS:

PAST HISTORY:

PERSONAL HISTORY:

FAMILY HISTORY:

TREATMENT HISTORY:

GENERAL PHYSICAL EXAMINATION

VITALS:

PR:

BP:

RR:

TEMP:

EYES-PALLOR:

ICTERUS:

CYANOSIS:

CLUBBING:

ABDOMINAL GIRTH:

SYSTEMIC EXAMINATION:

PER ABDOMEN:

INSPECTION:

PALPATION:

PERCUSSION:

AUSCULTATION:

CENTRAL NERVOUS SYSTEM:

CARDIOVASCULAR SYSTEM:

RESPIRATORY SYSTEM:

RADIOLOGICAL INVESTIGATIONS-

USG ABDOMEN AND PELVIS:

ECG-

INVESTIGATIONS: CBC:

1. HAEMOGLOBIN		
2. TLC		
3. NEUTROPHIL		
4. LYMPHOCYTE		
5. PLATELET COUNT		

RFT:

S. UREA			
S. CREATININE			
S. SODIUM			
S. POTASSIUM			
S. CALCIUM			

LFT:

T.B.				
CONJ/UNCON.				
SGOT				
SGPT				
ALBUMIN				
GLOBULIN				
ALP				

PT-INR:

PT (T)			
PT (C)			
INR			

VIRAL MARKERS:

HIV	
HBsAg	
HCV	

PULMONARY FUNCTION TEST:

FEV1/FVC	**FVC%**	**FEV1 % Predicted**	**Change in FEV1**	**Change in FVC**	**Any other finding**

ARTERIAL BLOOD GAS ANALYSIS:

PH			
PCO2			
PO2			
HCO3			
LACTATE			

CHILD PUGH SCORE:

1. ASCITES			
2. HE			
3. S. BILIRUBIN			
4. S. ALBUMIN			
5. PT OR INR			
CLASS			

MELD SCORE:

1. S. BILIRUBIN		
2. S. CREATININE		
3. PT-INR		
MELD SCORE		

CONCLUSION:

Date:-

Signature:- **DR. R.M.HONNUTAGI**

ANNEXURE IV

MASTER CHART

Sl NO	NAME	AGE	GENDER	IP NUMBER	USG	ABG	pH	PCO2	PO2	HCO3	SO2	PFT	FVC(PRE/POST)	FEV1(PRE/POST)	FEV1/FVC(PRE/POST)	FEF(25-75%)(PRE/POST)	SCORE	MELD SCORE
1	Umakanth	48y	Male	256515	Hepatomegaly,Splenomegaly,Moderate Ascites	Metabolic Alkalosis	7.46	25.1	83.5	20	95.6	Restrictive Pattern	Pre-64%,Post-70%	Pre-57%,Post-76%	Pre-90%,Post-89%	Pre-46%,Post-65%	C(11)	19
2	Yallappa M Mulawad	50y	Male	220410	Hepatomegaly,Splenomegaly,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.43	29.5	99	20.7	97	Restrictive Pattern	Pre-66%,Post-69%	Pre-62%,Post-70%	Pre-95%,Post-103%	Pre-46%,Post-64%	C(11)	17
3	Shrishail Shrimanth Biradar	35y	Male	202522	Hepatomegaly,Splenomegaly,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.47	25.5	104.2	21.5	97.6	Restrictive Pattern	Pre-60%,Post-63%	Pre-59%,Post-58%	Pre-104%,Post-111%	Pre-64%,Post-83%	C(11)	14
4	Kalmesh Aloor	40y	Male	258448	Hepatomegaly,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.49	25.7	65.9	21.8	94.9	Restrictive Pattern	Pre-60%,Post-67%	Pre-57%,Post-62%	Pre-106%,Post-109%	Pre-62%,Post-90%	C(11)	23
5	Jinnappa Ramu Teradal	60y	Male	268417	Hepatomegaly,Splenomegaly,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.44	20.7	58.1	16.5	92	Restrictive Pattern	Pre-66%,Post-65%	Pre-66%,Post-67%	Pre-100%,Post-101%	Pre-66%,Post-64%	C(11)	11
6	Sambaji S Madar	46y	Male	303675	Shrunken Liver,Splenomegaly,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.36	29.2	55.9	17.6	89.3	Obstructive Pattern	Pre-59%,Post-67%	Pre-51%,Post-41%	Pre-86%,Post-68%	Pre-43%,Post-30%	C(11)	19
7	Ramesh Benakanahalli	45y	Male	341378	Altered Liver Echotexture,Moderate Ascites	Respiratory Alkalosis	7.50	29.9	65.3	24.5	94.7	Restrictive Pattern	Pre-57%,Post-53%	Pre-58%,Post-54%	Pre-103%,Post-103%	Pre-61%,Post-54%	C(11)	16
8	Nanagouda Sahebgouda Biradar	45y	Male	339285	Hepatomegaly,Splenomegaly,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.46	30.8	60.4	21.7	92.9	Restrictive Pattern	Pre-28%,Post-30%	Pre-28%,Post-25%	Pre-113%,Post-106%	Pre-35%,Post-38%	C(11)	18
9	Mahantesh C Talawar	39y	Male	347993	Hepatomegaly,Portal Hypertension,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.42	30.7	82.2	21.1	96.4	Restrictive Pattern	Pre-51%,Post-53%	Pre-55%,Post-62%	Pre-110%,Post-118%	Pre-60%,Post-97%	C(11)	19
10	Gouri Shankar Math	24y	Male	308909	Hepatomegaly,Splenomegaly,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.48	26.7	90.3	22.6	97.7	Restrictive Pattern	Pre-50%,Post-49%	Pre-53%,Post-52%	Pre-105%,Post-105%	Pre-56%,Post-55%	C(12)	19
11	Basappa Yalaguradappa Bevoor	39y	Male	305947	Hepatomegaly,Splenomegaly,Minimal Ascites	Respiratory Alkalosis	7.47	31.2	80.9	24.1	96.7	Restrictive Pattern	Pre-68%,Post-69%	Pre-70%,Post-74%	Pre-81%,Post-84%	Pre-64%,Post-82%	B(9)	21
12	Laxman Bhimappa Kadapatti	42y	Male	349122	Hepatomegaly,Splenomegaly,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.47	28.9	82.6	22.4	96.9	Restrictive Pattern	Pre-60%,Post-56%	Pre-58%,Post-55%	Pre-97%,Post-98%	Pre-47%,Post-47%	C(13)	22
13	Hussainsab Allabaksh Attar	42y	Male	390081	Hepatomegaly,Cholelithiasis,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.45	22.8	88.5	19.3	97.3	Restrictive Pattern	Pre-44%,Post-52%	Pre-39%,Post-49%	Pre-89%,Post-95%	Pre-29%,Post-39%	C(13)	30
14	Siddaram Kallayya Hiremath	52y	Male	358675	Hepatomegaly,Splenomegaly,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.48	22	93.1	19.7	97.7	Restrictive Pattern	Pre-48%,Post-50%	Pre-50%,Post-51%	Pre-106%,Post-104%	Pre-54%,Post-56%	C(10)	14
15	Vittal Bhimappa Arasunagi	42y	Male	393272	Hepatomegaly,Splenomegaly,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.47	28.3	33.4	21.6	69.9	Restrictive Pattern	Pre-67%,Post-74%	Pre-67%,Post-72%	Pre-101%,Post-98%	Pre-69%,Post-68%	C(10)	16
16	Appashi Satteppa Jiragal	45y	Male	271793	Splenomegaly,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.46	24.7	103.2	20.1	97.5	Restrictive Pattern	Pre-38%,Post-43%	Pre-36%,Post-41%	Pre-95%,Post-97%	Pre-28%,Post-34%	C(10)	18
17	Srinath Kamble	39y	Male	004708	Splenomegaly,Moderate Ascites	Respiratory Alkalosis	7.47	32.3	87.7	24.7	96.6	Restrictive Pattern	Pre-42%,Post-41%	Pre-45%,Post-46%	Pre-108%,Post-115%	Pre-55%,Post-87%	C(10)	20
18	Mallappa Halli	35y	Male	004455	Splenomegaly,Mild Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.45	27.1	80.3	21.8	95.2	Normal Spirometry	Pre-70%,Post-83%	Pre-70%,Post-80%	Pre-85%,Post-81%	Pre-66%,Post-57%	B(8)	13
19	Rajendra Ramanna Daragakar	52y	Male	380387	Splenomegaly,Mild Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.42	26.4	81.3	19.5	96.4	Restrictive Pattern	Pre-68%,Post-59%	Pre-66%,Post-60%	Pre-98%,Post-102%	Pre-57%,Post-59%	B(8)	12
20	Ashwina Kumar Donur	38y	Male	038660	Splenomegaly,Mild Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.41	22.7	96.9	17.4	97.3	Restrictive Pattern	Pre-58%,Post-59%	Pre-61%,Post-60%	Pre-105%,Post-102%	Pre-65%,Post-57%	C(11)	20
21	Shekhar Shashidhar Kundalagi	35y	Male	041117	Altered Liver Echotexture,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.40	20	91.5	15.3	96.2	Restrictive Pattern	Pre-62%,Post-63%	Pre-68%,Post-69%	Pre-105%,Post-106%	Pre-55%,Post-71%	C(10)	16
22	Mahadevappa Gurupadappa Guddadagi	45y	Male	0050224	Splenomegaly,Moderate Ascites,Cystitis	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.48	24	86.8	20.7	96.4	Restrictive Pattern	Pre-68%,Post-71%	Pre-66%,Post-68%	Pre-105%,Post-103%	Pre-59%,Post-58%	C(11)	21
23	Praveen Mannur	42y	Male	0056381	Hepatomegaly,Splenomegaly,Mild Ascites	Respiratory Alkalosis	7.48	29.9	64.3	23.8	92.4	Restrictive Pattern	Pre-67%,Post-66%	Pre-70%,Post-68%	Pre-108%,Post-107%	Pre-77%,Post-63%	C(10)	17
24	Ashok Annappa Badiger	44y	Male	380492	Splenomegaly,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.46	29	99	22.5	97.3	Restrictive Pattern	Pre-66%,Post-67%	Pre-63%,Post-64%	Pre-97%,Post-97%	Pre-54%,Post-55%	B(9)	10
25	Maruti Laxman Sanadi	45y	Male	0090408	Splenomegaly,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.38	30.3	39.8	18.8	71.5	Restrictive Pattern	Pre-45%,Post-48%	Pre-53%,Post-54%	Pre-119%,Post-113%	Pre-102%,Post-85%	C(11)	26

26	Bhagesh Babugouda Patil	35y	Male	179862	Splenomegaly,Gross Ascites	Respiratory Alkalosis	7.50	32.3	82.3	26.6	95.7	Restrictive Pattern	Pre-53%,Post-59%	Pre-52%,Post-49%	Pre-99%,Post-100%	Pre-50%,Post-54%	C(11)	15
27	Guranna Kondagulli	56y	Male	243359	Hepatomegaly,Cholelithiasis,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.46	24	80.7	20.6	96	Restrictive Pattern	Pre-54%,Post-52%	Pre-53%,Post-51%	Pre-99%,Post-99%	Pre-49%,Post-46%	C(11)	14
28	Ravatappa Shivappa Hadapad	50y	Male	419934	Splenomegaly,Moderate Ascites,Cholecystitis	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.48	29.3	80.2	23.2	95.6	Restrictive Pattern	Pre-62%,Post-58%	Pre-74%,Post-72%	Pre-122%,Post-124%	Pre-90%,Post-110%	C(12)	21
29	Ramesh Lalu Rathod	49y	Male	333632	Splenomegaly,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.40	23.1	104.3	16.4	97	Restrictive Pattern	Pre-61%,Post-68%	Pre-62%,Post-70%	Pre-102%,Post-103%	Pre-60%,Post-77%	C(11)	27
30	Irappa B Nagathan	61y	Male	268060	Splenomegaly,Cholelithiasis,Gross Ascites	Metabolic Acidoosis	7.31	32.6	90.1	16	98	Restrictive Pattern	Pre-74%,Post-72%	Pre-74%,Post-75%	Pre-100%,Post-104%	Pre-73%,Post-88%	B(9)	15
31	Mallikarjun Hanamanth Navi	48y	Male	0064365	Altered Liver Echotexture,Moderate Ascites	Respiratory Alkalosis	7.46	34.1	31.7	24.2	70	Restrictive Pattern	Pre-63%,Post-68%	Pre-62%,Post-65%	Pre-98%,Post-96%	Pre-54%,Post-52%	C(13)	30
32	Bhimanna Hanamanth Naikodi	35y	Male	0058551	Mild Hepatomegaly,Mild Ascites	Respiratory Alkalosis	7.50	30.5	94.5	24.7	97.5	Restrictive Pattern	Pre-63%,Post-64%	Pre-66%,Post-70%	Pre-105%,Post-111%	Pre-85%,Post-111%	A(6)	9
33	Nadisab Kashimsab Keshapur	39y	Male	0033855	Hepatomegaly,Splenomegaly,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.41	31	73.7	21	95.2	Restrictive Pattern	Pre-58%,Post-61%	Pre-59%,Post-61%	Pre-103%,Post-102%	Pre-69%,Post-68%	C(12)	21
34	Babu Shankarappa Bhajantri	62y	Male	0042607	Splenomegaly,Gross Ascites,Portal Hypertension	Wnl	7.41	40.5	89.9	25.2	98.6	Restrictive Pattern	Pre-62%,Post-58%	Pre-66%,Post-62%	Pre-106%,Post-107%	Pre-77%,Post-68%	B(8)	6
35	Sanju Gondale	38y	Male	133788	Altered Liver Echotexture,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.42	26	81.4	17.7	90.8	Restrictive Pattern	Pre-76%,Post-78%	Pre-65%,Post-68%	Pre-86%,Post-87%	Pre-40%,Post-42%	C(11)	24
36	Suresh Shrishail Naikodi	45y	Male	200550	Altered Liver Echotexture,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.45	23.2	34.1	18.4	92.8	Restrictive Pattern	Pre-61%,Post-62%	Pre-69%,Post-70%	Pre-114%,Post-114%	Pre-110%,Post-100%	C(11)	20
37	Mallappa Sangappa Benki	48y	Male	186922	Altered Liver Echotexture,Splenomegaly	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.45	22.9	96.9	19.8	90.6	Restrictive Pattern	Pre-70%,Post-73%	Pre-69%,Post-70%	Pre-102%,Post-105%	Pre-102%,Post-105%	B(7)	15
38	Bhimappa Yamanappa Mundoganur	48y	Male	204863	Portal Hypertension,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.46	25.9	87.5	20.9	96.2	Normal Spirometry	Pre-79%,Post-79%	Pre-87%,Post-88%	Pre-111%,Post-112%	Pre-103%,Post-96%	B(8)	24
39	Shankar Babu Naik	47y	Male	214138	Hepatomegaly,Splenomegaly	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.44	26.7	91.5	19.8	94.4	Normal Spirometry	Pre-70%,Post-72%	Pre-85%,Post-86%	Pre-123%,Post-122%	Pre-120%,Post-121%	A(6)	12
40	Chandrashekar Mallikarjun Angadi	52y	Male	256709	Hepatomegaly,Splenomegaly,Gross Ascites	Wnl	7.40	37.6	33.2	23	62.6	Normal Spirometry	Pre-77%,Post-79%	Pre-86%,Post-88%	Pre-112%,Post-112%	Pre-114%,Post-127%	B(9)	16
41	Shivanand Jawwar	50y	Male	261419	Altered Liver Echotexture,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.36	27.4	60.9	17	87.8	Restrictive Pattern	Pre-47%,Post-47%	Pre-45%,Post-46%	Pre-97%,Post-99%	Pre-40%,Post-41%	C(12)	20
42	Sachin Sharanappa Arakeri	30y	Male	259116	Hepatomegaly,Splenomegaly,Mild Ascites	Metabolic Acidoosis	7.29	36.4	34.8	13.4	61.8	Restrictive Pattern	Pre-53%,Post-47%	Pre-53%,Post-43%	Pre-101%,Post-91%	Pre-48%,Post-33%	C(10)	18
43	Gousa Mujawar	40y	Male	237301	Altered Liver Echotexture,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.46	29.8	92.9	22.7	96.4	Restrictive Pattern	Pre-70%,Post-71%	Pre-60%,Post-62%	Pre-86%,Post-88%	Pre-37%,Post-37%	C(11)	15
44	Rajendra Shivappa Koppad	40y	Male	271991	Hepatomegaly,Splenomegaly,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.41	28.2	98.2	15.4	96.5	Restrictive Pattern	Pre-60%,Post-60%	Pre-60%,Post-63%	Pre-102%,Post-106%	Pre-60%,Post-72%	C(12)	23
45	Hanumanth Ravatappa Ganager	44y	Male	280703	Altered Liver Echotexture,Moderate Ascites	Wnl	7.37	45.9	55.2	24.6	64.7	Normal Spirometry	Pre-88%,Post-88%	Pre-95%,Post-97%	Pre-109%,Post-111%	Pre-127%,Post-140%	C(10)	18
46	Prasad Gobbur	27y	Male	035557	Altered Liver Echotexture,Splenomegaly	Respiratory Alkalosis	7.49	28.2	75.1	23.5	94.3	Restrictive Pattern	Pre-70%,Post-76%	Pre-67%,Post-77%	Pre-97%,Post-102%	Pre-54%,Post-75%	B(9)	11
47	Madimalayya K Hiremath	47y	Male	279149	Altered Liver Echotexture,Moderate Ascites	Respiratory Alkalosis	7.51	30.1	62.8	25.4	91.3	Normal Spirometry	Pre-109%,Post-109%	Pre-107%,Post-103%	Pre-81%,Post-78%	Pre-103%,Post-99%	B(9)	14
48	Prabhu Chandrashekar Alal	42y	Male	262770	Altered Liver Echotexture,Minimal Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.45	29.8	62.1	21.7	78.2	Normal Spirometry	Pre-86%,Post-85%	Pre-84%,Post-86%	Pre-82%,Post-84%	Pre-71%,Post-81%	B(7)	12
49	Santhosh Shivaji Vaddar	18y	Male	13328	Altered Liver Echotexture,Splenomegaly	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.41	32.5	96.1	21.2	97	Normal Spirometry	Pre-96%,Post-101%	Pre-100%,Post-106%	Pre-104%,Post-105%	Pre-104%,Post-103%	A(6)	7
50	Prakash Nayak	37y	Male	14273	Hepatomegaly	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.50	20.7	75.7	19.7	95.6	Normal Spirometry	Pre-113%,Post-110%	Pre-118%,Post-117%	Pre-104%,Post-106%	Pre-120%,Post-127%	A(6)	11
51	Kamalabai Meghu Chavan	54y	Female	12297	Altered Liver Echotexture,Minimal Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.42	30.1	94.2	21.1	96.7	Normal Spirometry	Pre-89%,Post-92%	Pre-87%,Post-94%	Pre-97%,Post-104%	Pre-71%,Post-87%	B(8)	15
52	Abhimanyu Sharanappa Goundi	56y	Male	14004	Altered Liver Echotexture,Minimal Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.47	26.8	86.2	21.7	90	Restrictive Pattern	Pre-71%,Post-74%	Pre-69%,Post-71%	Pre-98%,Post-98%	Pre-57%,Post-59%	B(8)	13
53	Laxman Shankar Jutti	42y	Male	13108	Altered Liver Echotexture,Splenomegaly	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.41	30.7	82.6	20.9	94.7	Normal Spirometry	Pre-86%,Post-89%	Pre-83%,Post-95%	Pre-96%,Post-106%	Pre-70%,Post-106%	B(7)	14
54	Babugouda Hanumanthraygouda Biradar	52y	Male	15464	Altered Liver Echotexture,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.42	25.1	43.6	18.3	79.2	Restrictive Pattern	Pre-51%,Post-54%	Pre-54%,Post-55%	Pre-107%,Post-105%	Pre-58%,Post-55%	C(10)	13
55	Shrimanth Kamalakar Kallur	46y	Male	15477	Hepatomegaly	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.46	22.3	77.3	18.5	94.9	Normal Spirometry	Pre-81%,Post-85%	Pre-80%,Post-85%	Pre-99%,Post-95%	Pre-73%,Post-80%	A(6)	13
56	Sagar Kaaldeep	30y	Male	16015	Altered Liver Echotexture,Hepatomegaly	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.51	23.1	82.6	22.3	90.2	Restrictive Pattern	Pre-34%,Post-36%	Pre-34%,Post-36%	Pre-101%,Post-100%	Pre-34%,Post-33%	A(6)	12
57	Sangappa Layappa Inchager	60y	Male	18231	Hepatomegaly,Splenomegaly,Minimal Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.42	27.7	90.5	20.2	96.4	Normal Spirometry	Pre-96%,Post-96%	Pre-90%,Post-93%	Pre-95%,Post-98%	Pre-70%,Post-73%	B(8)	11
58	Sadashiv Hanamanth Dani	45y	Male	17987	Hepatomegaly,Splenomegaly,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.40	21.2	47.9	15.3	81.4	Restrictive Pattern	Pre-64%,Post-67%	Pre-60%,Post-62%	Pre-95%,Post-92%	Pre-52%,Post-54%	B(8)	6

59	Suresh Hariba Ghatage	50y	Male	17650	Altered Liver Echotexture,Moderate Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.40	25.6	76.7	15.8	93.9	Restrictive Pattern	Pre-82%,Post-91%	Pre-75%,Post-87%	Pre-91%,Post-95%	Pre-55%,Post-71%	B(9)	8
60	Amasidda Kallappa Pujari	30y	Male	16400	Altered Liver Echotexture,Splenomegaly	Metabolic Acidosis	7.21	21.4	36	10.3	61.4	Normal Spirometry	Pre-90%,Post-92%	Pre-99%,Post-105%	Pre-109%,Post-114%	Pre-109%,Post-114%	B(9)	20
61	Sahebgouda Somanna Kakhandaki	45y	Male	17108	Altered Liver Echotexture,Minimal Ascites	Respiratory Alkalosis	7.50	28.6	76.2	25.3	94.5	Normal Spirometry	Pre-71%,Post-71%	Pre-75%,Post-84%	Pre-106%,Post-109%	Pre-79%,Post-109%	B(8)	10
62	Srinath Ram Kamble	45y	Male	17423	Splenomegaly,Gross Ascites	Respiratory Alkalosis With Compensatory Metabolic Acidosis	7.37	28	61.8	16	73.9	Restrictive Pattern	Pre-38%,Post-29%	Pre-36%,Post-32%	Pre-96%,Post-111%	Pre-30%,Post-39%	C(11)	25
63	Somanagouda Prabhugouda Patil	40y	Male	18885	Altered Liver Echotexture,Moderate Ascites	Wnl	7.38	44.6	84	24.2	92	Restrictive Pattern	Pre-67%,Post-72%	Pre-68%,Post-71%	Pre-101%,Post-99%	Pre-60%,Post-61%	C(11)	15
64	Mahesh Veerabhadrappa Kajagar	49y	Male	15984	Altered Liver Echotexture,Minimal Ascites	Respiratory Alkalosis	7.50	30.9	73.5	23.9	94.1	Restrictive Pattern	Pre-60%,Post-61%	Pre-59%,Post-59%	Pre-97%,Post-99%	Pre-51%,Post-51%	C(10)	20
65	Tukaram Ramu	38y	Male	10684	Portal Hypertension,Gross Ascites	Metabolic Acidosis	7.30	20.2	88	12.6	99.7	Normal Spirometry	Pre-97%,Post-103%	Pre-99%,Post-109%	Pre-102%,Post-106%	Pre-99%,Post-120%	B(9)	23