"Assessment of grade of hepatic fibrosis in Non-Alcoholic Fatty Liver Disease using Shear Wave Elastography – A one year hospital based cross sectional study"

BY

REG NO. BS0122011

Dissertation

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Sub: Institutional Ethical Clearance for the study.

With reference to the above, we wish to inform you that your proposed research project titled **"ASSESSMENT OF GRADE OF HEPATIC FIBROSIS IN NON ALCOHOLIC FATTY LIVER DISEASE USING SHEAR WAVE ELASTOGRAPHY- A ONE YEAR HOSPITAL BASED CROSS SECTIONAL STUDY",** is ethical and justifiable. The proposed research project has been cleared by the JNMC Institutional Ethics Committee.

(Dr. Smita Sonoli)
Member Secretary
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J.N.Medical College, Belagavi.

(Dr. Harsha Hegde)
Chairman,
JNMC Institutional Ethics Committee
J.N.Medical College, Belagavi

LIST OF ABBREVIATIONS

NAFLD	Non-Alcoholic Fatty Liver Disease
NASH	Non-Alcoholic Steato-Hepatitis
BMI	Body Mass Index
MAFLD	Metabolic Dysfunction Associated Fatty Liver Disease
MASLD	Metabolic dysfunction associated steatotic liver disease
METALD	MASLD and increased alcohol intake
ALD	Alcohol associated Liver disease
PCOS	Polycystic ovarian syndrome
HTN	Hypertension
CKD	Chronic kidney disease
NCD	Non Communicable Diseases
SWE	Shear wave elastography
SE	Strain elastography
HBV	Hepatitis B Virus
HCV	Hepatitis C virus
ROI	Region Of Interest
(M-STB)	Motion Stability Index
(RLB) map	Reliability map
IQR/M	Interquartile range-to-median ratio
LB	Liver biopsy
ARFI	Acoustic Radiation Force Impulse
AUC	Area Under the Curve
BT	Blood transfusion

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1) INTRODUCTION

As we enter the period of epidemiological transition, there is gradual shift from the morbidity and mortality related to communicable diseases towards non communicable and man-made diseases. Non-Alcoholic Fatty Liver Disease (NAFLD) has recently emerged as a concerning public health problem.

NAFLD is defined as the presence of steatosis in > 5% of hepatocytes in the absence of other competing chronic liver diseases and without significant alcohol consumption (< 20 g/day in women and < 30 g/day in men). Literature suggests that NAFLD will replace Hepatitis C as a major cause of chronic liver disease in the next decade and thus become a major cause of liver transplantation. [(5)]

NAFLD is a global health issue and the spectrum includes [(6)]:

1.NAFL (Non-Alcoholic Fatty Liver or simple steatosis) – excessive fat accumulation in the liver parenchyma with little or no inflammation or liver cell damage. It is a silent disease with no symptoms. 80-90 % of the cases show no progression and have good prognosis.

2. NASH (Non-Alcoholic Steato-Hepatitis)- inflammation and liver cell damage in addition to fat accumulation, setting stage for future complications

3. Advanced fibrosis

4. Cirrhosis

NAFLD is silent killer and an important cause of liver disease in India with estimated prevalence of 9-32 % (in general population) [(2)], 30-90% in overweight and obese and 40-80% in diabetics.[(7)]

Several mechanism that lead to development of NAFLD include [(8)]:

1.Oxidative stress – imbalance between in the pro and antioxidants

2.Production and release of toxic cytokines by inflammatory cells, liver cells and fat cells

3. Liver cell death or apoptosis

4. Adipose tissue inflammation or infiltration by the by white blood cells

5.Gut microbiota may have a role

Risk factors of NAFLD and other cardiovascular diseases show a significant overlap. [9] This indicates that NAFLD is just the tip of the iceberg and many other metabolic and cardiovascular diseases are awaiting to be revealed.

In Asian countries like India, 7-20% of the NAFLD subjects in different studies showed higher risk of Type II Diabetes Mellitus even at a lower BMI (<23 kg/m^2) compared to the other ethnicities associated with genetic predisposition. This is referred to as the Lean NAFLD or the Asian Paradox. Management is more challenging in such cases. [10]

Fat accumulation in the liver can be because of alcohol consumption, certain medications, viral hepatitis , autoimmune, metabolic or inherited liver disease. These causes should be excluded in order to confirm the diagnosis of fatty liver (Alcohol consumption is <30g/day for men and <20 g/day for women).

The definition of NAFLD is based on exclusion. Recent studies suggested that the nomenclature of NAFLD should be updated to MAFLD (Metabolic Dysfunction Associated Fatty Liver Disease) as the diagnosis of MAFLD should be based on the presence of metabolic dysfunction not the absence of other conditions. Metabolic associated fatty liver disease is a complex phenotype shaped by the dynamic interaction of genetic predisposition with environmental factors and components of the metabolic syndrome. [11]

The spectrum of steatotic liver disease include[12]:

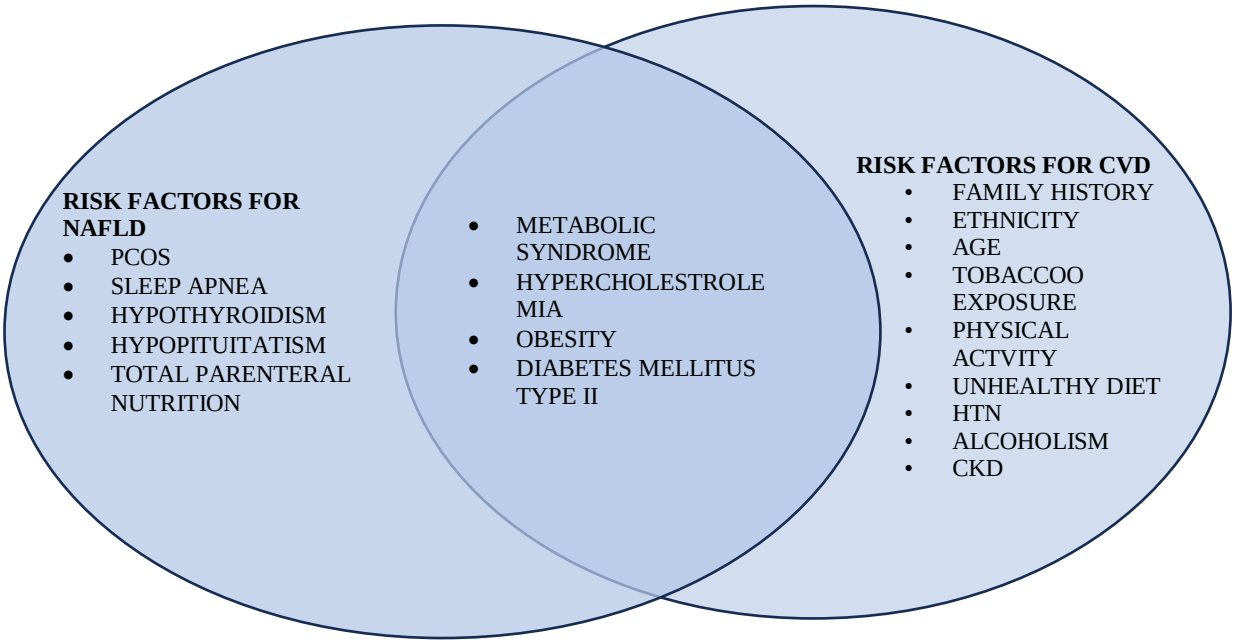
- MASLD -Metabolic dysfunction associated steatotic liver disease
- METALD – MASLD and increased alcohol intake
- ALD – Alcohol associated Liver disease
- Specific etiology associated -drug induced , monogenic and miscellaneous
- Cryptogenic

India contributes high numbers for Non Communicable Diseases globally and one of the core causes of metabolic diseases is liver. Realizing the growing burden and urgent need to address it, India became the first country to integrate the NAFLD in the National Programme for Prevention and Control of NCDs in 2021.

The guidelines focus on health promotion and early detection which are important for ensuring that patients with NAFLD receive timely and appropriate care. It also advocates for a multidisciplinary approach, integrating the efforts of healthcare providers from various discipline to offer a holistic care to individual affected by NAFLD. [13]

There is a growing evidence that fibrosis has a great influence on the hepatic and extra-hepatic mortality as compared to simple steatosis or even NASH without fibrosis [14]. Early fibrosis is reversible if the underlying insult is removed. Hence, it is vital that fibrosis be diagnosed at the earliest for NAFLD patients. [15]

Grey scale ultrasound can help detect and grade the amount of hepatic steatosis. However, blood test and ultrasound do not provide adequate information regarding the amount of fibrosis in the liver which is possible with liver biopsy that comes with its own set of limitations like life threatening complications , poor acceptability , sampling variability and cost.



(Graph no 1 : overlap in the risk factors NAFLD and CVD)

FIB-4 and NFS are the serum biomarkers to rule out advanced fibrosis.

Shear Wave Elastography(SWE) has diagnostic efficacy comparable to liver biopsy and overcomes the limitations of its invasive counter part.

Ultrasonography is an non invasive simple tool for the early detection of fatty liver in asymptomatic patients [(16)].Elastography can help quantify the stiffness of liver and predict the liver related morbidity.

Considering the magnitude of the problem of NAFLD , its inclusion into the NPNCD, this study was undertaken with the aim to assess the grade of hepatic fibrosis using shear wave elastography in patients detected to have Non-Alcoholic Fatty Liver Disease on grey scale ultrasound and to evaluate use of Shear wave elastography as a non-invasive screening tool in preventive radiology.

2) REVIEW OF LITERATURE

HISTORICAL BACKGROUND:

Ultrasound is an imaging modality that uses high-frequency sound waves (ultrasonic sound waves) of >2 kHz to characterize biological tissues. The discovery of ultrasound dates back to the 19th century when the Jacques and Pierre Curie noted that electricity may be created in a crystal of quartz on mechanical vibration. This phenomenon was termed the '***Piezoelectric effect'***.

Palpation is an age old effective method for detection of tissue abnormality based on changes in tissue stiffness or elasticity and provides the earliest indication of disease, even when conventional imaging studies are normal.

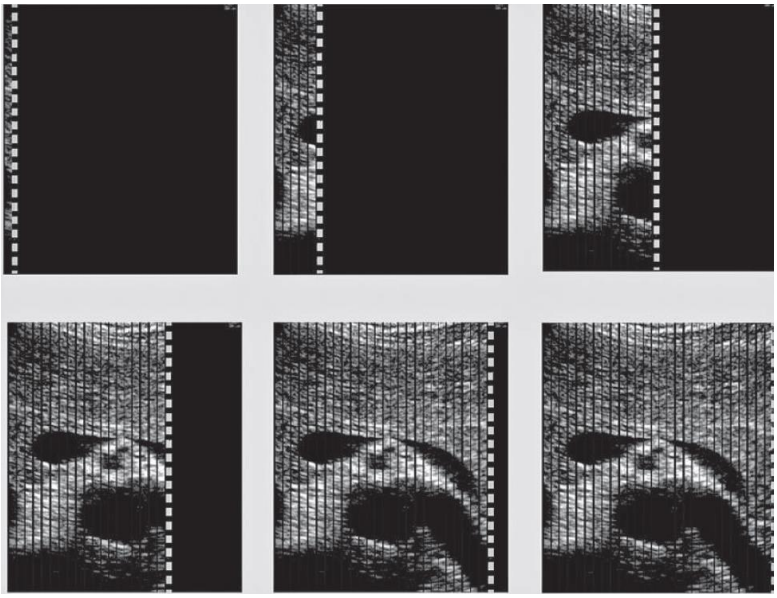
Liver biopsy (LB) remains the "gold standard" for assessment of liver fibrosis. However, liver biopsy has its own limitations like invasiveness, sampling error, and intra/inter-observer variability in histological interpretation. Furthermore, repeated biopsy examinations within a short time interval are indeed not feasible in a real clinical practice. [(18)]

Ultrasound elastography is emerging as a non-invasive qualitative and quantitative imaging technique to assess the tissue elasticity.

GENERATION OF IMAGE IN B MODE ULTRASOUND:

To generate a 2-D USG image, multiple ultrasound pulses are sent down a series of successive scan lines building a 2-D representation of echoes arising from the object being scanned.

When an ultrasound image is displayed on a black background , absence of signal is shown as black , signals of greatest intensity appear as white and signals of intermediate intensity appear as shades of gray.



(Figure 1: A two-dimensional (2-D), real-time image is built by ultrasound pulses sent down a series of successive scan lines. Each scan line adds to the image, building a 2-D representation of echoes from the object being scanned. In real-time imaging, an entire image is created 15 to 60 times per second.)

ULTRASOUND ELASTOGRAPHY: [19]

Ultrasound imaging is based on tissue bulk modulus which reflects interactions at the molecular level. Changes in tissue stiffness based on the tissue shear modulus is an important indication of disease. Ultrasound elastography provides relative and quantitative assessment of tissue stiffness.

Tissue stiffness or elasticity is expressed by **Young modulus -**

Ratio of compression pressure (stress) and the resulting deformation (strain) is the young modulus

$$\mathbf{E = \sigma / \varepsilon}$$

Where, E is Young modulus (expressed in Pa (pascals))

σ is the stress (expressed in Newtons)

ε is displacement (expressed in m^2)

Ultrasound-based elastography permits study of the elastic behaviour of tissue through two general approaches :

A) Strain elastography (SE):

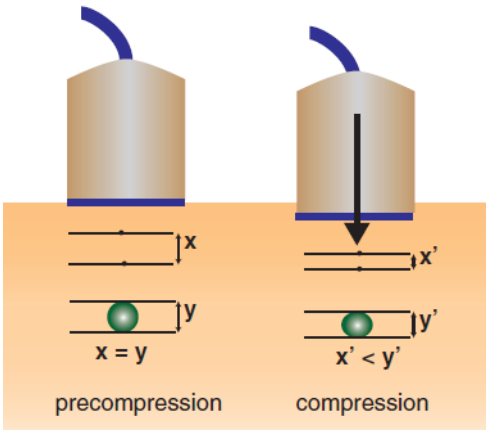
In Strain elastograms , images of tissue stiffness are generated by analysis of speckle displacements before and after mechanical compression of tissue.

The precompression and post compression frames are compared.

SE is qualitative and indicates only the relative hardness or softness of lesions compared to their surroundings.

It is useful in superficial accessible diseases.

Disadvantages: it is operator dependent, has bad reproducibility and not suitable for liver.



(Figure 2: Strain elastography: In this example, the lesion is compressed much less than the surrounding tissue, indicating relative stiffness)

Shear wave elastography (SWE):

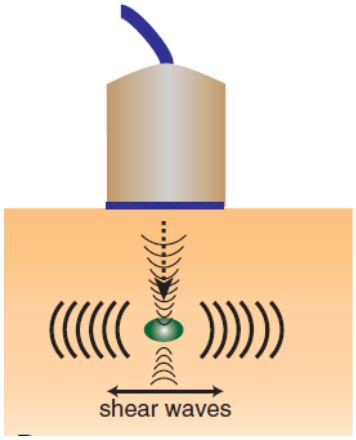
When high-intensity compression pulses from the transducer are focused on the area of interest it results in generation of low-frequency shear waves.

Speckle displacement resulting from these shear (transverse) waves is tracked with multiple imaging frames in order to estimate shear wave velocity.

Shear wave velocity is directly related to Young modulus, permitting a quantitative estimate of tissue stiffness (strain modulus).

It is useful in diffuse diseases and deeper tissues.

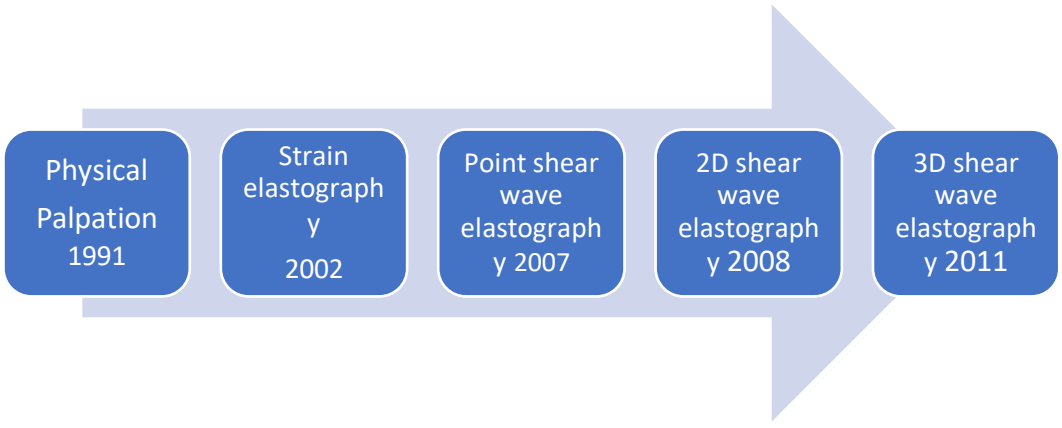
Advantages: it is operator independent and has good reproducibility



(Figure 3: Shear wave elastography: Shear waves are generated by repetitive compression produced by high-intensity pulses from the ultrasound transducer and Shear waves are tracked with high frame rate images to determine their velocity)

The rationale behind elastography is that normal liver is soft organ, and not favourable for wave propogation while fibrosis increase the tissue hardness and favours more rapid propagation.

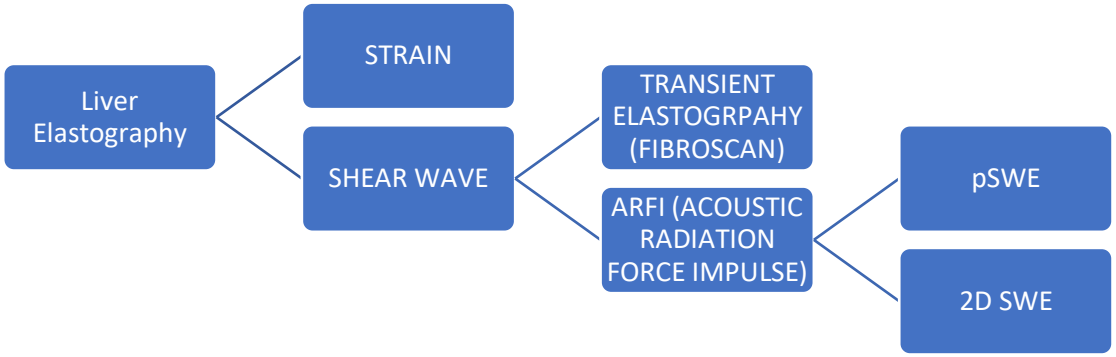
EVOLUTION OF ELASTOGRAPHY TECHNIQUE :



(Figure 4: Evolution of elastography technique)

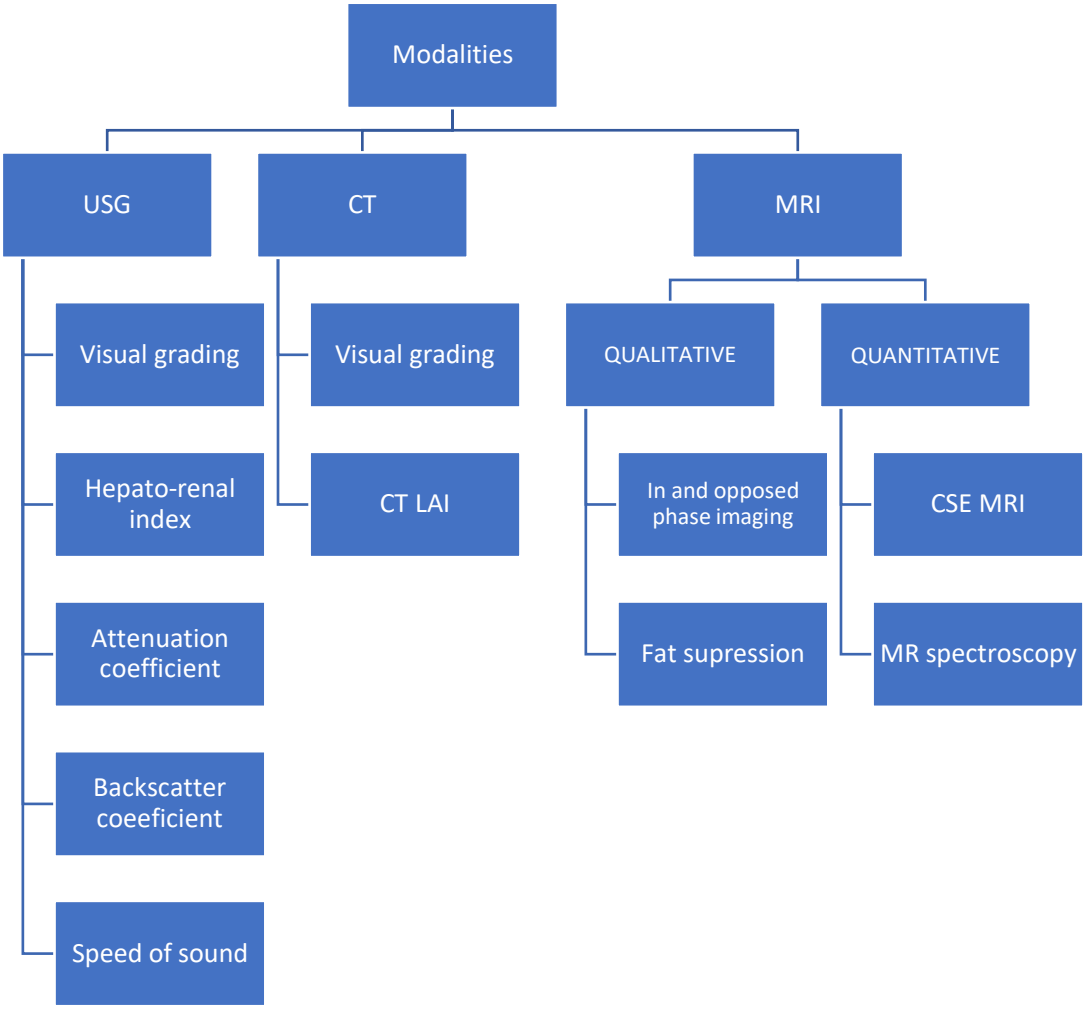
Physical palpation was the ancient technique for the assessment of the organ stiffness. Over the years there was search for other ways to know the tissue composition. Although liver biopsy was the diagnostic test for tissue assessment, it came with its own share of limitations. So the search continued to find non invasive yet reliable options to know organ stiffness. Ultrasound elastography was remedy to this problem. As the technique evolved and improvised the readings could reliably predict the tissue composition and overcame the limitations of the invasive counterpart.

TYPES OF LIVER ELASTOGRAPHY TECHNIQUES :



(Figure 5: Types of liver elastography techniques)

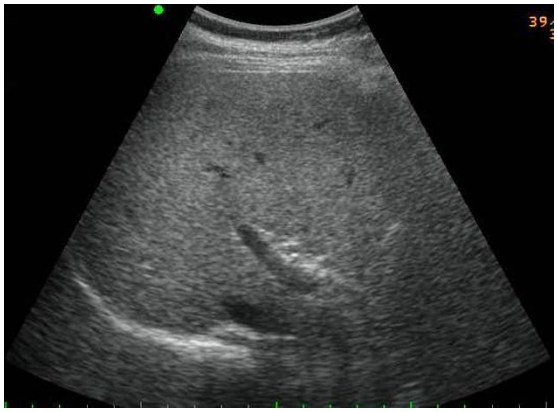
MODALITIES FOR ASSESSING THE HEPATIC STEATOSIS :



(Figure 6 : Modalities for assessing the hepatic steatosis)

GRADES OF FATTY LIVER ON B-MODE ULTRASOUND (Figures 7,8,9) :[20]

- **Grade I:** diffusely increased hepatic echogenicity but periportal and diaphragmatic echogenicity is still preserved



- **Grade II:** diffusely increased hepatic echogenicity obscuring periportal echogenicity but diaphragmatic echogenicity is still preserved

- **Grade III:** diffusely increased hepatic echogenicity obscuring periportal as well as diaphragmatic echogenicity

ULTRASOUND ELASTOGRAPHY OF LIVER:

Pre-requisites: [21]

- 4 hours of fasting
- Proper visualisation through the intercostal spaces
- Neutral breathing
- 15-20 mm below the liver capsule
- Atleast 5 measurements
- IQR/Median <30% for kPas

RED FLAGS ON LIVER ELASTOGRAPHY : [22]

- Advanced fibrosis (>F3)
- Elastography values >/=8 kPa (1.7m/s)
- Sudden change in values on follow up

REVIEW OF STUDIES:

1. Arka De et al, in their review article, mention the prevalence of NAFLD among general population in India to be between 9 to 53% while that in costal south India to be 49.8%. [23]

2. Liver biopsy is indicated in establishing the diagnosis, staging and/or prognostication, and for treatment planning for a variety of conditions like viral, autoimmune, cholestatic, steatotic , storage and metabolic disease related , hepatopathy of unknown cause and neoplastic etiologies. Liver biopsy can be acquired by Percutaneous ultrasound-guided, Laparoscopic or Transjugular routes. Percutaneous technique is simple, rapid, inexpensive but is associated with the potential

complications like post-interventional hemorrhage and bile leakage, other organ injuries and rarely bacteremia. Laparoscopic liver biopsy yields more information than percutaneous liver biopsy because it enables macroscopic inspection of the hepatic surface. This technique is also associated with the risk of hemorrhage. Transjugular routes is preferred option in patients with severe coagulopathies however carries the risk of complications of jugular catheter placement. [(24)]

3. Liver stiffness can be measured by Transient elastography , Shear wave elastography, Acoustic radiation force impulse imaging and Magnetic resonance elastography. Platelet count, bilirubin, soluble CD163, aspartate aminotransferase—to-platelet ratio index (APRI), FibroTest , Forns index, Lok index and FibroIndex are all laboratory-based measures that have been described in the assessment of fibrosis. [(25)]

4. BN Vinyasa et al conducted a study in Mysuru, Karnataka on 154 participants. The participants were assessed for presence and grade of steatosis using Ultrasonography followed by Shear Wave Elastography (SWE)and NAFLD Fibrosis score. They found out a good level of agreement between SWE and NAFLD fibrosis score and concluded that SWE showed good diagnostic performance in detection of fibrosis. [(26)]

5. Arinc Ozturk et al, conducted a study on 132 patients undergoing liver biopsy and subjected them to SWE. They found that AUC (Area Under the Curve) of SWE was 0.79 with a threshold value of 8.37 kPa yielding a high sensitivity of 90% and specificity of 65%. From the results they offered evidence that SWE can be a low cost, non -invasive tool suitable for widespread adoption. The study however had certain limitations like its retrospective design, use of single ultrasound machine not allowing generalisation and inherent subjectivity of histopathological analysis. [(27)]

6. Yin-Yan Li, in their study to investigate the clinical application of ultrasonic elastography in quantitative assessment of fatty liver grading found that Ultrasonic

elastography technique, in comparison to traditional ultrasound, had a high consistence in grading of fatty liver [κ value = (95.3%- 63.6%)/(1%-63.6%) = 0.87, P = 0.001]. The score of ultrasonic elastography increased with the severity of fatty liver with a sensitivity of 97.14% and a specificity of 91.11%. [28]

7. Jie Yan et al conducted a study on 3762 residents of Beijing selected by random multistage stratification and cluster sampling. Through questionnaire, physical examination, biochemical and radiological examination, the study tried to assess the prevalence of fatty liver and its risk factors. They concluded that prevalence of fatty liver amongst residents of Beijing was 35.1% and that obesity, elevated blood glucose, and deranged lipid profile are the main risk factors for development of fatty liver. [29]

8. Rijo M. Choorakuttil et al , in their study performed shear wave elastography on 852 subjects and gave the Distribution of Normative Percentiles of Liver Stiffness Measurement Using Ultrasound Shear Wave Elastography in an Adult Asian Indian Population (Table 1). The same cut-offs were used in the present study to grade the fibrosis. [30]

Parameter	*N* (%) 95% CI	Interpretation
< 5 kPa	56 (6.57%) 5.10, 8.44	High probability of being normal
< 9 kPa	496 (58.22%) 54.87, 61.48	In the absence of other clinical signs, rules out cACLD. Needs further tests based on clinical signs
9–13 kPa	200 (23.47%) 20.75, 26.44	Suggestive of cACLD but needs further evaluation
> 13 kPa	58 (6.81%) 5.30, 8.7	Rules in cACLD
> 17 kPa	42 (4.91%) 3.67, 6.60	Suggestive of CSPH

9. Stephen E. ConglyI et al, performed a study to assess the cost-effectiveness of various non-invasive strategies to diagnose the high-risk patients for NAFLD. The study concluded that SWE based strategies were the most cost effective for diagnosing >F2 fibrosis. For >F3 fibrosis, FIB-4 followed by SWE was the most effective and least costly strategy. [31]

10. Hiroka e.t al, in their review article discussed about the spectrum of Ultrasonography artifacts in hepatic 2D SWE , emphasizing the importance of knowing these artifacts while interpreting elastography results. They gave some important recommendation to reduce the artefacts during elastography like [32] :

- When performing 2D-SWE in patients with chronic hepatic disease, especially liver cirrhosis, it is recommended to measure shear wave values through the least irregular hepatic surface
- The most useful 2D-SWE in patients with focal lesion will detect lesions that are poorly visible on B-mode ultrasound and will differentiate true tumors from pseudo-tumors (*e.g.* irregular fatty change)
- Measurement of shear wave values in the area posterior to a focal lesion must be avoided.

11. Indian Radiological & Imaging Association in their Multicenter study on the magnitude and risk of NAFLD based on SWE measurements used the following questionnaire: [33]

Participating Center, Investigator and Patient Identifiers:

1. Name of Center
2. Email ID:
3. Name of Doctor
4. District
5. State
6. Study Subject ID

Demographics:

Age of patient in years :

Height in Meters :

Sex of Patient Weight in Kgs :

Occupation :

Waist Hip Ratio :

Co-morbidity (Yes/No) : (Table no 2)

Diabetes Mellitus		Ischemic Heart Disease	
BMI ≥30		Hypertension	
Metabolic Syndrome		Hypothyroidism	
Sleep Apnoea		Day time Drowsiness	
Prior Hepatitis		Dyslipidemia	
PCOS (if female)		Menopause (If Female)	

Others-1 (Specify)		Others-2 (Specify)	

Personal Risk Behaviour (Table no 3):

Consumption	Never	Daily	>Twice a week	> Once a Week	Irregular
At least 30 ml alcohol					
Tobacco use					
Junk/Deep Fried/Oily/Packaged Food					
Exercise/Moderate to intense physical activity for at least 30 minutes					
Coffee Drinking	Never	Black coffee 1-3 cups daily	Black Coffee > 3 cups daily	Only with milk and sugar	Irregular

Family Member has NAFLD/NASH: Any Parent/ Any Sibling/ Any Child/ Spouse/ Any Cousin/ None

Biochemical Parameters

SGOT/AST :

FBS :

HbA1C :

Lipid Profile : - Normal/Abnormal

SGPT/ALT:

PPBS

Referral indication :

Self referred / clinical service referral ;

Primary clinical indication for the study:

SWE :

Make of the machine used for SWE :

Patient position : Left lateral/ supine

	1	2	3	4	5	6	7	8	9	10
Stiffness value range (kPa)										

(Table 4 : SWE value)

Median :

Interquartile range :

Interquartile / median :

Mean :

M -STB stars (if applicable)

RLB Stars (if applicable)

Skin Capsule Distance (cms):

	1	2	3	5	6
Liver attenuation(if available)					
Hepatorenal Index (if available)					

(Table No 5 : USG findings)

Liver Surface (using Linear high resolution probe): smooth / irregular/ Nodular

Micronodules (using Linear high resolution probe): present / absent

Staging by SWE (check appropriate column) (Table No 6):

<5 kPa (1.3m/s)	<9 kPa (1.7 m/s)	9-13 kPa (1.7-2.1 m/s)	>13 kPa(2.1m/s)	>17 kPa (2.4m/s)

Were there any difficulties in the assessment of this case? specify if any:

3) AIM AND OBJECTIVES

AIM

Assessment of grade of hepatic fibrosis in Non-Alcoholic Fatty Liver Disease using Shear Wave Elastography

OBJECTIVES

- To investigate the use of shear wave elastography in assessment of fibrosis in patients detected to have Non-Alcoholic Fatty Liver Disease on grey scale ultrasound
- To study correlation between the grade of hepatic stiffness on Shear wave elastography with the grade of steatosis on B-mode Ultrasound in NAFLD
- To study correlation between the grade of hepatic stiffness on Shear wave elastography with the known risk factors of NAFLD

4) MATERIALS AND METHODS

This study was undertaken from 1 January 2024 to 31 December 2024, patients were referred for an USG Abdomen to the department of Radiodiagnosis at KLE's Dr Prabhakar Kore Hospital & MRC, Belgaum, Karnataka, India.

Source of Data: Patients referred to Radiology Department of KLE's Dr. Prabhakar Kore Hospital & Medical Research Centre, Belagavi

Study Design: It was a Hospital based Cross sectional

Study Type: Observational study

Study Period: The study duration was 2 years (Jan 1st ,2024 to December 31st ,2024)

Sample Size:

Calculated sample size for the study was 43. Based on previous studies the global prevalence of Non Alcoholic Fatty Liver Disease is 25.2 %.[17] Considering the prevalence of 25%, sensitivity of the test of 90% and absolute precision of 18%, the calculated sample size is 43 which was rounded off and a total of 53 cases were collected during the study.

Sample size is calculated by the formula –

$a+c=z^2S(1-S)/d^2$

$(a+b+c+d)= P(a+c)$

{(a+c)-total disease positive, Z-1.96 for 95% confidence limit, S- estimated sensitivity of 0.9, d- Absolute precision of 0.18, P-prevalence of disease of 0.25}

New test	Gold standard		Total
	Positive	Negative	
Positive	9.67(a)	3.225(b)	12.9(a+b)
Negative	1.075(c)	29.025(d)	30.1(c+d)
Total	10.75(a+c)	32.25(b+d)	43(a+b+c+d)

(Table no 7: Calculation of the sample size)

Sampling technique: using Systemic Random Sampling (every alternate patient of Non Alcoholic Fatty Liver Disease was included till the sample size was achieved)

Inclusion Criteria:

1. Patients detected to have fatty liver on ultrasonography, irrespective of their gender, visiting Radiology Department of KLE's Dr. Prabhakar Kore Hospital & Medical Research Centre, Belagavi willing to participate
2. Patients with previous ultrasonography reports suggestive of presence of fatty liver

Exclusion Criteria:

1. Patients with excessive alcohol consumption which is defined as intake of more than 20g /day for women and more than 30g/day for men
2. Patients who had developed advanced liver disease
3. Patients with chronic viral hepatitis (HBV and HCV serology)
4. Patients with other metabolic diseases (Autoimmune hepatitis, Hemachromatosis,

Wilson's disease, Alpha -1 anti trypsin deficiency)

5. Paediatric population (age less than 18 years)

Ethical consideration ;

Institutional Ethical Clearance from Institutional Ethics Committee for Human Subjects Research of Jawaharlal Nehru Medical College, Belagavi, Karnataka was obtained.

Participants received informed written consent and only those participants willing to sign the informed consent were included in the research.

Before obtaining consent the participants were informed about the risks and benefits involved in the research and the voluntary nature of participation. The confidentiality of the participants in this research was preserved.

Data collection procedure:

A pre-designed pre-tested questionnaire was used for interviewing the participants. Demographic data, Medical history, Anthropometric data , findings on B mode Ultrasonography and 2D shear wave elastography were recorded and later tabulated in Ms Excel.

Measuring tape and weighing machine were used for recording the height (in cms) and weight (in kgs) of the participants.

Study tool : *Mindray Resona i9 ultrasound machine equipped with curvilinear probe (1-6m Hz)*

Examination technique:

The above-mentioned study population who met the inclusion criteria and did not get excluded were subjected to ultrasonography of the right hypochondriac region in supine with arm abducted using *'Mindray Resona i9'* Ultrasonography machine equipped with a *curvilinear probe SC6-1s* (1-6 mHz) was used for detection of fatty liver and grading the steatosis.

Shear Wave Elastography feature of the same machine was used for assessment and grading of hepatic fibrosis.

B mode images and the elastography images were stored securely on a portable storage drive.

PRACTICAL STEPS IN THE LIVER ELASTOGRAPHY – [17]

(Recommendations may vary slightly based on vendor-specific recommendations related to the instrument used)

1. The patient should be nil by mouth for atleast 4 hours prior to the elastography study. This is an important as the liver stiffness values increase after a meal in patients with chronic liver disease and can lead to erroneous staging of NAFLD.

2. Linear high-resolution probe to assess the liver surface for irregularities and presence or absence of micronodules (< 2 mm in size).

3. Patient is positioned in left lateral position at 30 degrees and with the right arm raised above the head to increase the width of the intercostal space to survey the liver in B-mode. If not able to maintain the left lateral position or are unable to hold breathing in the left lateral position, assessment can be performed in supine position.

4. Optimize the good quality B-mode image showing the liver capsule as a white line without rib's or lung's shadowing in the liver parenchyma.

5. Search for the best acoustic window by intercostal approach with the transducer held at 90 degrees perpendicular to the liver capsule.

6. Upper edge of the sampling box is placed at least 1 to 2 cm below the liver capsule (to avoid reverberation artifacts) and whenever possible avoid including any large vessels, and small vessels.

7. Size of the ROI could be very large, however it is recommended to choose a size that reduces the possibility of including artifacts, which may degrade the sample quality. An ROI of 2 to 3 cm in size is a good compromise to qualitatively assess the stiffness of the targeted liver parenchyma area possibly without artifacts.

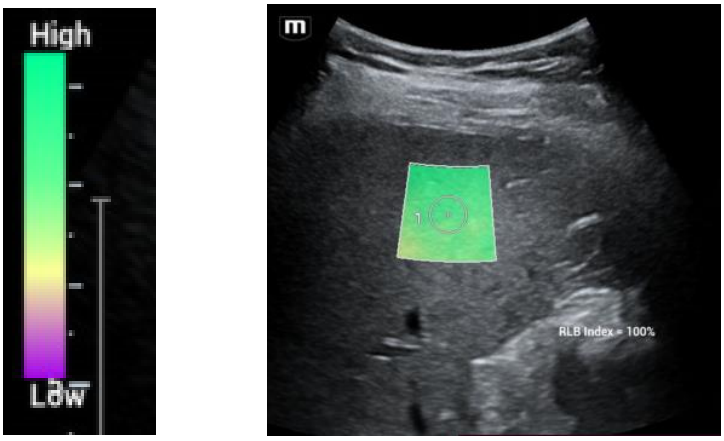
8. Place the ROI box in the center of the B-mode image in a homogeneous area of the liver parenchyma, avoiding ligaments, vessels, or bile ducts.

9. Hold the probe steady and ask the patient to hold the breath for a few seconds (in mid expiration) and place the targeted segment at the center the image.

10. Observe both B-mode and SWE display, coded with colors, side by side when the patient holds breath in neutral position. The elastography mode is activated by the examiner after the elastogram is stable for five consecutive frames.

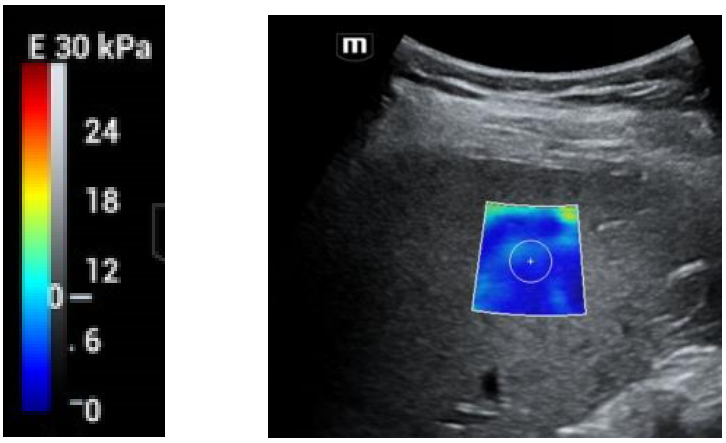
11. Wait for the system to generate consecutive frames and capture sequential images in a cine loop.

12. Best possible frames are indicated by the reliability indices of each vendor-specific machine. These may include the five green stars motion stability (M-STB) index and reliability (RLB) map with full green color as good shear wave quality, color-coded confidence maps, signal-to-noise ratio, and stability index. Avoid measurements on elastograms of poor quality and reliability.



Confidence scale Color-coded confidence maps

(Figure 10: Confidence scale and Color-coded confidence maps to check the quality of the acquired image)

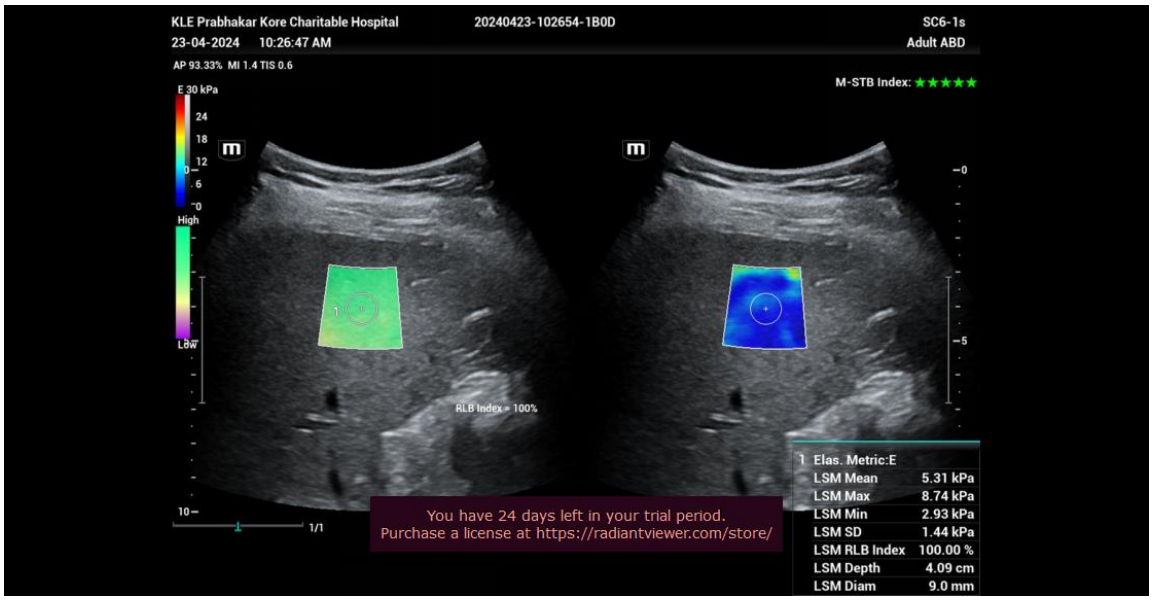


Colour scale Colour elastograms

(Figure 11: Colour scale and Color elastogram to check the tissue stiffness)

13. Use the measurement key to place the “circle” 15-mm diameter size within the ROI box in a homogenous colour area. For better accuracy, it is recommended to perform only one measurement for each acquisition either in m/s (speed of the shear waves) or kPa (stiffness value derived from the speed of the shear wave by using the Young module). The size of the “circle” can be reduced to 10 mm in case of artifacts within the ROI.

14. The colors captured in the ROI are related to the E scale, which goes from dark blue to dark red. As a rule, for routine assessment it is better to always use the same scale.



(Figure 12: Confidence map and the colour coded elastogram showing 5 green star indicating good motion stability, reliability index of 100% indicating good quality images. Circle is placed in the ROI box in homogenous colour area and the mean kPa values are recorded)

15. It is recommended to obtain a minimum of 5 high quality acquisitions and to use their median value as representative of the stiffness. The accuracy is not lost with five acquisitions of high quality with an interquartile range-to-median ratio (IQR/M)< 30% when the median value is given in kPa and <15% when the median value is given in m/s.

16. IQR/M is used as a quality factor to assess the variability between consecutive liver stiffness measures. The IQR/M should be 30% when the median value is given in kPa and 15% when the median value is given in m/s.

17. The liver stiffness is staged into five categories for clinical interpretation and radiological follow-up.

18. Activate the report box on the touch screen to auto-transfer the measurement data

to the table report page.

STATISTICAL ANALYSIS:

For descriptive statistics mean, mode , median and standard deviation were used.

For Inferential statistics, Kruskal Wallis test was applied to verify association between grades of liver stiffness with age and anthropometric variables viz. age, height . ANOVA test was applied to test the association between the grade of liver stiffness and grade of liver steatosis.

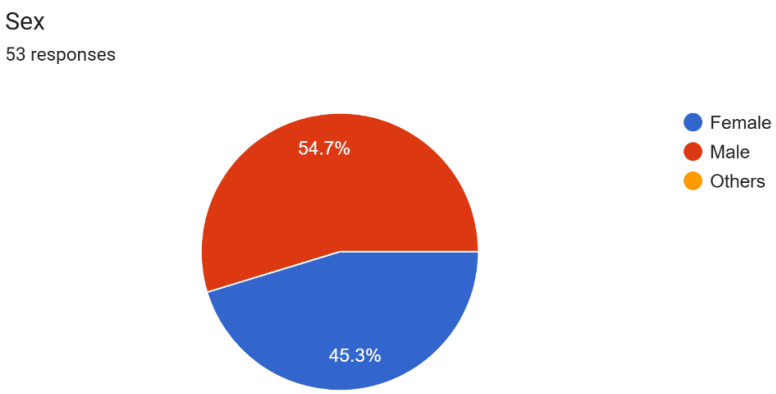
Chi square test as applied to see association between grades of liver stiffness and various risk factors like hypertension , hepatitis , history of blood transfusion , regular exercise, dietary habits, hepatomegaly , etc

5) RESULTS

The present cross-sectional study conducted on 53 participants visiting Radiology Department of KLE's Dr. Prabhakar Kore Hospital & Medical Research Centre, Belagavi. A pre-designed pre-tested questionnaire was used for interviewing the participants. Demographic data, Medical history, Anthropometric details, findings on B mode Ultrasonography and 2D Shear Wave Elastography were recorded, entered in Microsoft Excel and interpretated. Following results were obtained from the study.

Descriptive statistics

In our study, of the 53 participants, 29 (54.7 %) were male and 24 (45.3 %) were female.



(Graph 2: Sex distribution of the study population)

Age group in the study population ranged from 28 to 80 years, with a mean of ~49.5 years.

The mean height of the study population was 158.5 cms +/- 8.8 cms (163.4 cms +/-8.2 cms in males and 152.6 +/- 5.2 cms in females).

The mean weight of the study population Ranges from 46 to 102 kg, with a mean of ~71.2 kg (67.3 +/- 10.4 kg in females and 74.3 +/- 12.5 kg in males).

The mean BMI of the study population was on an average around 28.4, ranging from 22.5 to 41 (27.7 +/- 3.9 kg/m^2in males and 28.9+/ -4.7 kg/m^2 in females)

BMI Category Distribution:

Overweight: 48.1% (Largest group)

Obese Class I: 23.1%

Normal BMI: 19.2%

Obese Class II & III: 9.6%

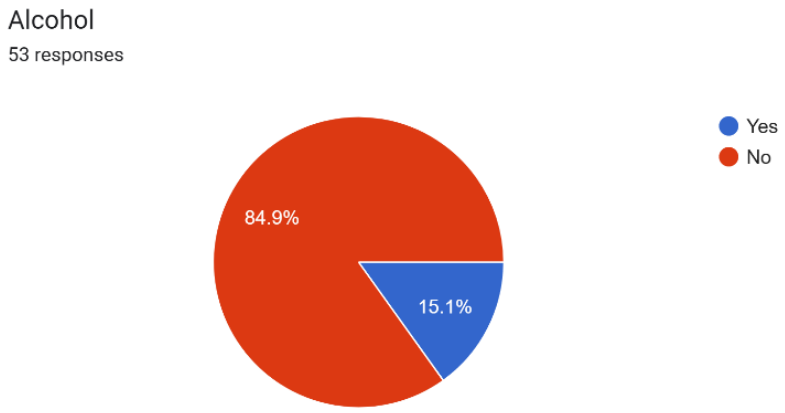
Underweight: 0%

Key Observation: A high percentage of patients are overweight or obese, a known risk factor for NAFLD.

Following were the dietary preferences of the study participants

- **Mixed Diet:** 41 patients (77.4%)
- **Vegetarian:** 11 patients (20.8%)
- **High Saturated Fat Consumption:** 1 patient (1.9%)

(Frequency of alcohol consumption in the study population (Graph no 3))



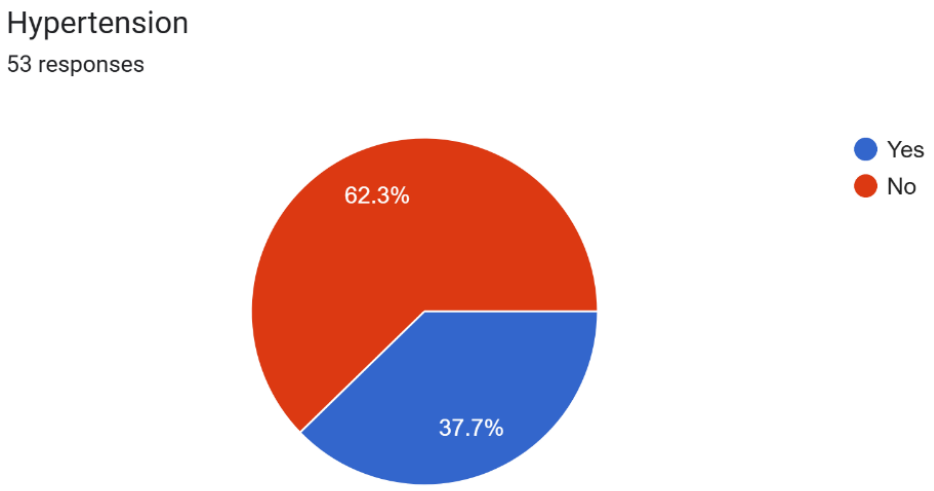
- It was observed that majority i.e 45 (84.9 %) patients were non alcoholic and 8 (15.1%) were consumed alcohol (however < 20 g/day in women and < 30 g/day in men in accordance to the inclusion criteria of the study).

Distribution of the study population according to occupation (Table no 8):

	Frequency	Per cent
Air Force	1	1.9
ARSA	1	1.9
Auto driver	1	1.9
Clerk	2	3.8
Cook	1	1.9
Coolie	1	1.9
Ex army man	1	1.9
Ex Army servicemen	1	1.9
Ex serviceman	1	1.9
Farmer	6	11.3
Framer	1	1.9
Gas factory worker	1	1.9
Housewife	17	32.1
Jail warden	1	1.9
Journalist	1	1.9
Labour	1	1.9
Lawyer	1	1.9
Nuclear power plant retired	1	1.9
Nurse	1	1.9
Pharmacist	1	1.9
Police	1	1.9
Police officer	2	3.8
Private company employee	1	1.9
Retired	1	1.9
Retired army man	2	3.8
Road traffic officer	1	1.9
Security gaurd	1	1.9
Tailor	1	1.9
Unemployed	1	1.9
Total	53	100.0

It was observed that most patient were housewife 17 (32.1 %), farming 6 (11.3%), clerical job (3.8%) , police officer 2 (3.8 %) , ex-serviceman 2 (3.8%) and one each in remaining category as mentioned in the table.

Frequency of hypertensives in the study population (graph 4):



It was observed that 20 (37.7 %) of the patients had hypertension and remaining 33 (62.3 %) were non hypertensive.

8 (15.0 %) of the study participants were diabetics and the rest were not known Diabetics.

It was seen that 27 (51.9 %) of the patients were not taking any drugs whereas, remaining 26 (49.1%) were on medication for hypertension , diabetes and thyroid disorders.

It was observed that majority of the patients 52 (98%) had no history of hepatitis while one (1.9 %) gave history of hepatitis.

6 (11.3 %) of the study participants gave history of blood transfusion, no patients had history of liver diseases and 23 (43.4 %) did regular exercise.

Majority of the patients i.e 41(77.4 %) took mixed diet while 11(20.8 %) were pure vegetarians , and one gave history of consumption of saturated fats.

It was seen that 2 (3.8 %) of the patients had deranged lipid profile. Record of lipid profile was not available for majority i.e 96.2% of the patients.

Fatty Liver Grade Distribution:

Grade I: ~67.9% (Most common finding: **Grade I Fatty Liver** (often with hepatomegaly)

Grade II: ~30.2%

Grade III: ~1.9%

→ Majority of patients have Grade I fatty liver, with a smaller percentage progressing to Grade II and very few with Grade III.

Liver Stiffness Grade Distribution:

As per the cut offs for quantifying fibrosis on SWE, we had-

Grade 0 - 2 (1.8 %)

Grade I - 36 (67.9 %)

Grade II - 15 (28.3 %)

Mean elastography values for liver stiffness on SWE: 8.02 kPa

Range: 4.0 – 12.3 kPa

Inferential statistics :

ELASTOGRAPHY			Age	Height	Weight	BMI
G0	N	Valid	2	2	2	2
		Missing	0	0	0	0
	Mean		56.500	160.000	68.500	27.2000
	Median		56.500	160.000	68.500	27.2000
	Std. Deviation		10.6066	4.2426	20.5061	6.64680
	Minimum		49.0	157.0	54.0	22.50
	Maximum		64.0	163.0	83.0	31.90
G1	N	Valid	36	36	36	36
		Missing	0	0	0	0
	Mean		47.972	158.319	70.056	27.8675
	Median		47.000	155.500	67.000	26.6000
	Std. Deviation		13.5720	9.1941	12.3333	4.11532
	Minimum		28.0	135.0	46.0	22.60
	Maximum		77.0	179.0	102.0	41.00
G2	N	Valid	15	15	15	15
		Missing	0	0	0	0
	Mean		52.267	158.867	74.200	29.5653
	Median		49.000	156.000	71.000	29.9000
	Std. Deviation		12.3547	8.7657	10.7318	4.69185
	Minimum		33.0	147.0	55.0	23.00
	Maximum		80.0	176.0	91.0	37.50
Kruskal Wallis Test	**P**		**0.40**	**0.76**	**0.28**	**0.50**

(Table no 9: correlation between the grade of liver stiffness with age , height , weight and BMI)

Association of different parameters with the grade of Fatty liver :

t-test or ANOVA for numerical comparisons (e.g., Age, Weight, Elastography across Grades) and **Chi-square test** for categorical comparisons (e.g., Sex, Exercise, Family History).

Age ($p = 0.233$) → No significant difference between Grade 1 and Grade 2 fatty liver ($p < 0.05$).

Sex (p = 0.233) → No significant association with fatty liver grade. This suggests that sex alone may not be a strong predictor of fatty liver severity in this dataset.

Weight (p = 0.008) → Significant difference between Grade 1 and Grade 2 fatty liver ($p < 0.05$).

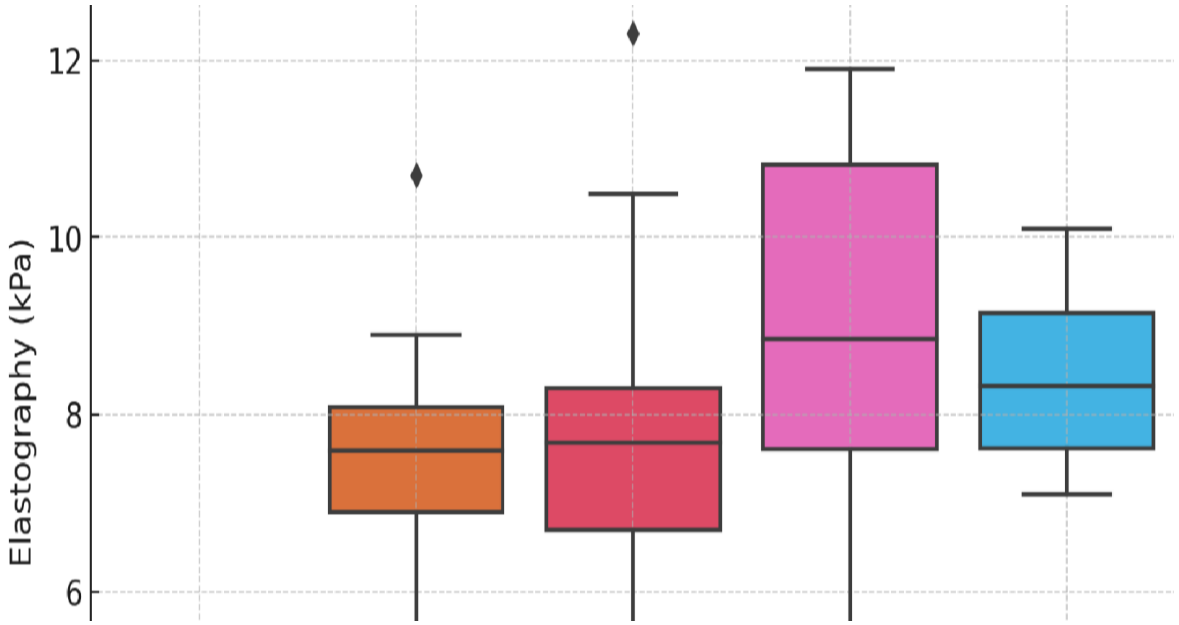
Family History of Liver Disease (p = 1.000) → No significant association.

Association of different parameters with the grade of liver stiffness on SWE :

(ANOVA to compare elastography findings across different fatty liver grades and **Correlation analysis** between elastography and weight, age, and other factors.)

On application, of Krushal-Wallis test to see association between liver stiffness (grade 0, 1 and 2) with age of patients p value was 0.4 (not significant).

In cases of grades of liver stiffness and weight p value was 0.76 (not significant).



(Graph no 5 : Elastography values across BMI categories)

- This **boxplot** suggests a slight increase in **elastography values (kPa)** with higher BMI categories.
- However, the **ANOVA test (p = 0.273)** shows **no statistically significant difference** in elastography values across BMI categories.
- This suggests that, in this dataset, **higher BMI does not strongly correlate with increasing liver stiffness.**

(Table no 10: Distribution of grades of liver stiffness and hypertension)

		Hypertension		Total
		No	Yes	
ELASTOGRAPHY	G0	1	1	2
	G1	22	14	36
	G2	10	5	15
Total		33	20	53

On applying chi square test to see whether there is association between grade of liver stiffness and hypertension, it was not statistically significant.

8 of the 52 study participants were known diabetics. No significant association between diabetes and fatty liver grades (Chi-square p = 0.397). Also there was no significant difference in elastography values between diabetic and non-diabetics (T-test p = 0.268).

(Table no 11: Distribution of grades of liver stiffness and hepatitis history)

		Hepatitis		Total
		No	Yes	
ELASTOGRAPHY	G0	2	0	2
	G1	35	1	36
	G2	15	0	15
Total		52	1	53

On applying, Chi square test to see association between grades of liver stiffness and hepatitis, it was found to be not significant statistically (p value : 0.78).

(Table no 12: Distribution of grades of liver stiffness and blood transfusion (BT) history)

		BT History		Total
		No	Yes	
ELASTOGRAPHY	G0	2	0	2
	G1	32	4	36
	G2	13	2	15
Total		47	6	53

On applying, Chi square test to see association between grade of fatty liver stiffness and history of blood transfusion. It was found to be statistically not significant (p value 0.85).

(Table no 13: Distribution of grades of liver stiffness and regular exercise)

		Regular exercise		Total
		No	Yes	
ELASTOGRAPHY	G0	2	0	2
	G1	19	17	36
	G2	9	6	15
Total		30	23	53

Regular Exercise ($p = 0.032$) → Significant association with fatty liver grade ($p < 0.05$). This suggests that regular exercise is significantly related to fatty liver grade, meaning exercise habits may influence severity of hepatic steatosis. However , there was found to be no statistically significant association between the grade of liver stiffness and regular exercise.

(Table no 14: Distribution of grades of liver stiffness and regular exercise)

		Dietary habits		Total
		Mixed diet	Vegetarian	
ELASTOGRAPHY	G0	2	0	2
	G1	28	8	36
	G2	12	3	15
Total		42	11	53

Since p > 0.05, there is no statistically significant association between dietary habits and fatty liver grades. (p-value = 0.789). And p-value = 0.865, there is no statistically significant difference in liver stiffness (kPa) between Vegetarians and Non-Vegetarians.

Association of hepatomegaly with different parameters :

(Table no 15: Distribution of grades of liver stiffness and hepatomegaly)

		Hepatomegaly		Total
		absent	present	
ELASTOGRAPHY	G0	2	0	2
	G1	28	8	36
	G2	8	7	15
Total		38	15	53

Hepatomegaly was found in 15 of the 53 study participants and was associated with higher elastography values, especially when combined with fatty liver.

Age (p = 0.479) → No significant difference between hepatomegaly groups.

Weight (p = 0.066) → Almost significant (borderline), indicating those with hepatomegaly tend to have higher weight. **Weight is slightly higher** in the hepatomegaly group, though not statistically significant.

Elastography Findings (p = 0.164) → No statistically significant difference. **Elastography values tend to be higher** in hepatomegaly cases, but the difference is not statistically significant.

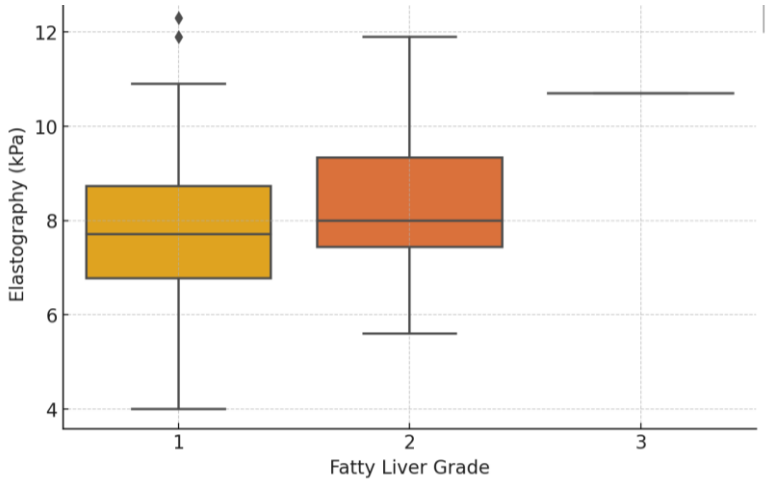
Fatty Liver Grade (p = 0.231) → No significant association between hepatomegaly and fatty liver grade. **No clear association between hepatomegaly and fatty liver grade.**

Elastography

The boxplot shows an increasing trend in elastography stiffness (kPa) as fatty liver severity worsens.

However, the ANOVA test (p = 0.161) indicates that the difference between fatty liver grades is not statistically significant at the standard $p < 0.05$ level.

This suggests that while elastography values tend to be higher in more severe fatty liver cases, the variation is not statistically significant in this dataset.



(Graph no 6: Elastography values with the grade of hepatic stiffness on SWE)

Although the **mean elastography values increase with fatty liver severity**, the **differences are not statistically significant** in this sample. This might be due to overlapping values and sample size limitations.

6) DISCUSSION

This research unveils the fact that Shear Wave Elastography is a novel technique in the non-invasive estimation of liver stiffness. It can be applied in the cases of Non-Alcoholic Fatty Liver Disease detected on B mode ultrasound for early detection, prognostication, treatment commencement and introduction of lifestyle modifications. Thus, diagnostic utility of this technique is paramount in preventive radiology. Our study found that the grade of liver stiffness increased with the grade of liver steatosis however there was no significant correlation between the two.

1. Prevalence and incidence of NAFLD are higher in men than in premenopausal women (or ≤ age 50–60 years) while they tend to become more common in women after menopause (or ≥ age 50–60 years). In our study, 29 (54.7 %) were male and 24 (45.3 %) were females. [33]

2.Jong seo yoon from their study conducted on 156 participants concluded that 2D-SWE can be used as a non-invasive diagnostic tool for diagnosing and assessing the severity of paediatric NAFLD**.** However, paediatric population (<18 years of age) was exclusion criteria for our study. Further studies are needed to ascertain the use of shear wave elastography in paediatric population. [34]

3.Annual NAFLD incidence rate in the people aged less than 50 years and more than 50 years were 3.5% and 5.5%, respectively in a 4-year longitudinal retrospective cohort study on 10,240 consecutive healthy individuals who received annual physical examination during 2012–2019 in China . [37] The Age Standardised Incidence Rate (ASIR) of Central Latin America was highest (6.88 per 100,000 persons) in the world, while most of the people were white race in Central Latin America. The ASIR of East Asia was 2.10 per 100,000 persons [38]. Therefore, NAFLD incidence rate appears to

differ by age in different race. In our study , majority of the participants had Grade I (67.9%), followed by Grade II (30.2%) and least had Grade III (1.9%)fatty liver.

4.Occupational stress is emerging as a major mental health issue that could lead to less cooperation, low productivity, regular absenteeism and poor quality of life. In a study conducted on police cohort in Tianjin, China to study the relationship between occupational stress based on OSI-R scores and the incidence of NAFLD. High Occupational Stress and High Personal Strain were found to be independent predictors for the development of NAFLD in a Chinese police population. In our study, majority of the participants were housewife 17 (32.1 %), farmers were 6 (11.3%), clerical jobs were done by (3.8%) , police officers were 2 (3.8 %) , 2 (3.8%) were ex-serviceman while rest were other less common professions. [(39)]

5.More severe NAFLD was associated with increased weight and BMI. Study by Ladan Aghakhani et al conducted on 228 severely obese individuals revealed that main risk factors of NAFLD in patients undergoing bariatric surgery were weight ($p = 0.002$) and BMI ($p = 0.003$). In our study also we found similar significant association between Grade 1 and Grade 2 fatty liver with the weight ($p = 0.008$). This indicates that the grade of Fatty liver increases with weight. [(40)]

6. In a study conducted by A. Katrina Loomis et al , there was a consistent and strong relationships between BMI and prospectively recorded diagnoses of NAFLD/NASH . Risk of recorded NAFLD/NASH increased linearly with BMI and was approximately 5times higher in Humedica (HR4.78, 95% CI 4.17–5.47) and 9 times higher in THIN (HR8.93, 7.11–11.23) at a BMI of 30 –32.5 kg/m2 and increased to around 10 times higher in Humedica (HR9.80, 8.49 –11.32) and 14 times higher in THIN (HR14.32, 11.04 –18.57) at the BMI category of 37.5– 40 kg/m2 BMI category. However, in our

study the association between the liver stiffness and BMI showed non-significant association (p value of 0.5). This indicates that although the weight reduction strategies are important for prevention and management of NAFLD, the possibility of Asian Paradox need to be taken into account. [41]

7. Moderate alcohol consumption can be harmful in liver-related NAFLD outcomes in patients with NAFLD/NASH, especially for those with risk factors like elderly age group, obesity, metabolic syndrome, viral hepatitis, and advanced liver disease. In our study 15.1% of the patients gave history of moderate or less alcohol consumption. (<30g/day in males and < 20g/ day in females).[42]

8. Emerging epidemiological evidence has demonstrated that ≈49.5% of hypertensive patients have NAFLD and the prevalence of hypertension is significantly higher in individuals with NAFLD than in the general population. 20 of the 53 patients in our study were known hypertensives, however there was no significant association between presence of hypertension and the grade of liver stiffness on elastography. [43]

9. Well-phenotyped prospective cohort of patients aged ≥50 years with T2DM, conducted on 524 patients it was found that the prevalence of advanced fibrosis was 14% and that of cirrhosis was 6%. This data underscores the high risk of advanced fibrosis/cirrhosis in adults aged ≥50 years with T2DM. In our study there was found no significant association between the grade of fibrosis and diabetes. [44]

10. Studies have reported that excessive consumption of carbohydrates, especially refined carbohydrates, fats (particularly saturated fats) and meat proteins can cause NAFLD . Higher intakes of soft drinks and meat are also associated with NAFLD in adults . In our study, 42 of the 53 patients gave history of consumption of mixed diet and there was no statistically significant difference between the type of diet and grade

of liver stiffness. [45]

11.The relation between hepatitis B and fatty liver is controversial . In a meta-analysis the risk of NAFLD was significantly lower in HBV-infected patients than in uninfected controls . They concluded, HBV infection was inversely associated with the risk of NAFLD. In our study , there was no statistically significant association between grades of liver stiffness and hepatitis (p value : 0.78). [46]

12. Physical exercise has a beneficial effect on NAFLD by reducing the hepatic fat content through improvements in insulin resistance, liver fatty acid metabolism, liver mitochondrial function, and activation of inflammatory cascades. However in our study, the grade of liver stiffness did not correlate with the regularity of exercise. [47]

13. Mild or moderate hepatomegaly is one of the most common physical examination findings in patients with NAFLD. Biochemically, patients with NAFLD may have hyperlipidemia, hyperglycemia, hyperinsulinemia, and reduced insulin sensitivity. In our study, 15 of the 53 patients had hepatomegaly, with almost significant (p value 0.066) association indicating those with hepatomegaly tend to have higher weight. The Elastography values tend to be higher in hepatomegaly cases, but the difference is not statistically strong (p = 0.164). And record of lipid profile was not available for majority of the patients. [48]

14.In the group of 8350 individuals studied by Hui-Yun Cheng et al , who underwent liver ultrasound scanning, steatosis was found in 34.40% (22.34% in males and 12.06% in females), of which 27.08% had mild steatosis, 6.49% had moderate fatty liver, and 0.82% had severe steatosis. Majority of patients have Grade I fatty liver (67.9%) , with a smaller percentage progressing to Grade II (30.2%) and very few with Grade III (1.9%). [49]

15. In a study by Li YY et al., the score of ultrasonic elastography increased with the severity of fatty liver with a sensitivity of 97.14% and a specificity of 91.11% & showed a positive correlation coefficient of 0.822. However in our study, there was no significant correlation between the grade of fatty liver and grades of hepatic steatosis.(50)

16. Yoneda M et al in their study found that there was a significant positive correlation between liver stiffness and the severity of liver fibrosis in patients with NAFLD on biopsy. However, no significant correlation was found between liver stiffness and severity of fibrosis with the grade of steatosis. Similarly in our study, no significant correlation was found between the grade of fibrosis and grade of steatosis. (51)

17. In a case control study conducted by Parag Patil et al on 41 healthy (controls) and 41 NAFLD patients (cases), point shear wave elastography was used to compare the liver stiffness. They reported that the mean liver stiffness was higher in patients with fatty liver compared to normal individuals. They also found positive correlation between the ultrasound grade of fatty liver and liver stiffness in NAFLD. In our study , 2D SWE was used and no significant correlation was found between the grade of fatty liver and grade of hepatic fibrosis. (52)

18. BN Vinyasa et al conducted a study in Mysuru, Karnataka on 154 participants. The participants were assessed for presence and grade of steatosis using Ultrasonography followed by Shear Wave Elastography (SWE)and NAFLD Fibrosis score. They found a good level of agreement between SWE and NAFLD fibrosis score and concluded that SWE showed good diagnostic performance in detection of fibrosis. However, in this study the 2D SWE values were not compared with the histological liver fibrosis stage.(53)

19. In a study conducted by Uffan Zafar on 207 patients with fatty liver detected on ultrasound, they found that according to Pearson's analysis, the grade of NAFLD had larger positive associations with triglycerides, total cholesterol, low-density lipoprotein, and fasting blood sugar. High density lipoprotein and C-reactive protein were found to have a negative correlation with the grade of NAFLD. In our study, most of the participants were asymptomatic patients referred for unrelated indications, record of lipid profile was not available for majority of the patients. [54]

7) CONCLUSION

Ultrasound is effective in detecting NAFLD , especially grade I and II. Elastography is a safe and non-invasive modality for the assessment of organ stiffness. Non alcoholic fatty liver disease has emerged as an important cause of increased liver related morbidity and mortality.

This study was conducted with the aim to determine the association between grade of hepatic steatosis on ultrasound and grade of fibrosis on elastography.

Elastography showed increasing trend of stiffness with increasing severity of fatty liver, but lacks statistical significance in this data set (p value of 0.17).

There was a significant positive association between Grade 1 and Grade 2 fatty liver with the Weight ($p = 0.008$). Higher BMI and age weakly correlated with increased liver stiffness.

There was a significant association with fatty liver grade suggesting that exercise habits may influence severity of hepatic steatosis. However, there was found to be no such association between the grade of liver stiffness and regular exercise. Hepatomegaly is a strong indicator of increased liver elastography values.

The study also found no significant correlation between grade of liver stiffness, alcohol consumption, presence of hypertension, history of blood transfusion and type of diet.

To conclude, ultrasound elastography is an effective way of screening liver for early detection of liver fibrosis. Integration of fatty liver elastography in routine screening can help in early diagnosis and initiation of treatment and can thus help overcome multitude of non-communicable metabolic disorders.

8) LIMITATIONS

Acknowledging the limitations of a study is essential for understanding the scope and potential implications of its findings. Our study had the following limitations:

1. The examination technique and small sample size are the limitations of the study.
2. Since the ultrasound technique depends on the examiner's skill, there are many intra and inter-observer variations
3. The patients who could hold breath during the study were excluded from the study as good quality images could not be obtained
4. Liver stiffness on elastography was not compared with the degree of liver fibrosis on biopsy
5. Prevalence of fatty liver and assessment of liver stiffness by elastography in paediatric obese patients was not attempted as patients <18 years of age were excluded from the study
6. Cases of focal fatty infiltration were not included in the study

9) SUMMARY

Non communicable diseases are on a rise. Opportunistic and targeted screening combined with radiological, pathological and genetic biomarkers is needed to develop an integrated diagnostic and screening approach for metabolic disorders.

NAFLD is just the tip of an iceberg and is associated with a wide spectrum of non-communicable diseases.

With the growing evidence that fibrosis has a great influence on the hepatic and extra-hepatic mortality as compared to simple steatosis or even NASH without fibrosis, Elastography can be incorporated in daily practice for non invasive estimation of liver stiffness.

In our study there was no significant association between the grade of fatty liver on grey scale ultrasound and the grade of liver stiffness on SWE (p value 0.17). Although the mean elastography values increased with fatty liver severity, the differences were not statistically significant in this sample. This might be due to overlapping values and sample size limitations.

This contradicted the popular belief that there is a positive correlation between the two parameters. This reinforces in the importance of early detection of liver fibrosis on SWE in absence of progression of the grade of steatosis on B mode ultrasound.

These evidences support need for early detection, patient education, lifestyle modification and integrated care strategies to improve health outcomes.

10) RECOMMENDATIONS

- Due to the alarming rates of NAFLD secondary to the changing lifestyle, screening by ultrasound combined with Shear wave elastography should be included in routine practice
- BMI remains an important risk factor, but other metabolic parameters should also be considered for future analysis
- Further studies with larger sample size may confirm the statistical significance of the elastography trend
- Further studies could be undertaken to study the prevalence of fatty liver in pediatric population and the correlation with elastography values

11) REFERENCES

1. Zobiar M Y et al , Contribution of alcoholic and non alcoholic fatty liver disease to the burden of liver related morbidity and mortality, Hepatology. 2016 July volume 64, issue 1,p.73-84
2. Arka De, Ajay Duseja, Non alcoholic Fatty liver disease: Indian Perspective, Clinical Liver Disease (Hoboken), vol 18 no.3, Sept 2021, p 158-163
3. Yoshioka S, Atsushi N, Yoshioka I, Limitations of liver biopsy and new diagnostic tests for the diagnosis of non alcoholic fatty liver disease / non alcoholic steatosis, World j Gastroenterol, 2014 Jan 14; 20(2), 475-485
4. National Guidelines Center (UK), Non alcoholic fatty liver disease : Assessment and Management, London: National Institute of Health and Care Excellence (NICE) ; 2016 July. (NICE Guidelines, no.49)2, Guidelines summary
5. Ajit Ramakant Mahale , Clinical relevance of reporting fatty liver on ultrasound in asymptomatic patients during routine health checkups , Journal of International Medical Research 2018, Vol. 46(11) 4447–4454
6. Ajay Duseja ,Non alcoholic Fatty liver disease in India-a lot done ,yet more required! Indian journal of Gastroenterology, 2010 Nov, (29):p 217-225
7. Brunt, E., Wong, VS., Nobili, V. *et al.* Nonalcoholic fatty liver disease. *Nat Rev Dis Primers* 1, 15080 (2015). https://doi.org/10.1038/nrdp.2015.80)
8. American college of Gastroenterology , https://gi.org/topics/fatty-liver-disease/nafld/
9. American college of Gastroenterology , https://gi.org/topics/fatty-liver-disease/nafld/

10. Dhamija E, Paul SB, Kedia S. Non-alcoholic fatty liver disease associated with hepatocellular carcinoma: An increasing concern. Indian J Med Res. 2019 Jan;149(1):9-17. doi: 10.4103/ijmr

11. Mohammed Eslam et al , MAFLD: A Consensus-Driven Proposed Nomenclature for Metabolic Associated Fatty Liver Disease, Gastroenterology Volume 158, Issue 7, May 2020, Pages 1999-2014

12. A multisociety Delphi consensus statement on new fatty liver disease nomenclature Rinella, Mary E. et al. Journal of Hepatology, Volume 79, Issue 6, 1542 – 1556

13. 1-Ministry of Health and Family Welfare ,Union Health Ministry Releases Revised Operational Guidelines and Training Manual of Non-Alcoholic Fatty Liver Disease: Posted On: 27 SEP 2024 12:21PM by PIB Delhi

14. Bertot LC, Adams LA. The natural course of non alcoholic fatty liver disease. Int [2]J Mol Sci. 2016;17(5):774.)

15. BN Vinyasa, Vikram P , Non invasive assessment of fibrosis in Non Alcoholic Fatty Liver Disease by Shear Wave Elastography and NAFLD fibrosis score: A cross sectional study, Journal of clinical and diagnostic research , 2022 Aug, vol-16(8), 06-10)

16. Ajit Ramakant Mahale , Clinical relevance of reporting fatty liver on ultrasound in asymptomatic patients during routine health checkups , Journal of International Medical Research 2018, Vol. 46(11) 4447–4454).

17. Ajit Ramakant Mahale , Clinical relevance of reporting fatty liver on ultrasound in asymptomatic patients during routine health checkups , Journal of International Medical Research 2018, Vol. 46(11) 4447–4454

18. Practical Steps of Shear Wave Elastography for Nonalcoholic Fatty Liver Disease in an Adult Population, Rijo Mathew Choorakuttil, Rajas N. Chaubal et al Indographics 2022;1:171–183.
19. Kim BK, Fung J, Yuen MF, Kim SU. Clinical application of liver stiffness measurement using transient elastography in chronic liver disease from longitudinal perspectives. World J Gastroenterol. 2013 Mar 28;19(12):1890-900. doi: 10.3748/wjg.v19.i12.1890. PMID: 23569334; PMCID: PMC3613104.
20. Diagnostic ultrasound, 5th edition , Carol M. Rumack and Deborah Levine ,chapter 1 ultrasound physics
21. Goel A, Knipe H, Campos A, et al. Diffuse hepatic steatosis (grading). Reference article, Radiopaedia.org (Accessed on 21 Jan 2025) https://doi.org/10.53347/rID-33279
22. Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement: Richard G. Bar, Stephanie R. Wilson, Deborah Rubens, Guadalupe Garcia-Tsao, and Giovanna Ferraioli, Radiology 2020 296:2, 263-274
23. Congly SE, Shaheen AA, Swain MG. Modelling the cost effectiveness of non-alcoholic fatty liver disease risk stratification strategies in the community setting. PLoS One. 2021 May 21;16(5):e0251741. doi: 10.1371/journal.pone.0251741)
24. Arka De, Ajay Duseja, Non alcoholic Fatty liver disease: Indian Perspective, Clinical Liver Disease (Hoboken), vol 18 no.3, Sept 2021, p 158-163)
25. Tannapfel A, Dienes HP, Lohse AW. The indications for liver biopsy. Dtsch Arztebl Int. 2012 Jul;109(27-28):477-83. doi: 10.3238/arztebl.2012.0477. Epub 2012 Jul 9. PMID: 22833761; PMCID: PMC3402072.

26. Lucero C, Brown RS Jr. Noninvasive Measures of Liver Fibrosis and Severity of Liver Disease. Gastroenterol Hepatol (N Y). 2016 Jan;12(1):33-40. PMID: 27330502; PMCID: PMC4865784.
27. BN Vinyasa, Vikram P , Non invasive assessment of fibrosis in Non Alcoholic Fatty Liver Disease by Shear Wave Elastography and NAFLD fibrosis score: A cross sectional study, Journal of clinical and diagnostic research , 2022 Aug, vol-16(8), 06-10
28. Ozturk A, Mohammad R, Pierce TT, KamarthiS, Dhyani M , Graco JR et al, Diagnostic accuracy of shear wave elastography as a non invasive bookmarker of high risk non alcoholic steatohepatitis in patients with Non alcoholic fatty liver disease, Ultrasound med biol, 2020 April, 46(4): 972-980
29. Li YY, Wang XM, Zhang YX, Ou GC. Ultrasonic elastography in clinical quantitative assessment of fatty liver. World J Gastroenterol. 2010 Oct 7;16(37):4733-7. doi: 0.3748/wjg.v16.i37.4733. PMID: 20872976; PMCID: PMC2951526.
30. Jie Yan et al , Epidemiological survey and risk factor analysis of fatty liver disease of adult residents, Beijing, China, journal of gastroenterology and hepatology , Volume28, Issue10 ,October 2013 , Pages 1654-1659
31. Rijo M. Choorakuttil, Rajas N. Chaubal et al . Distribution of Normative Percentiles of Liver Stiffness Measurement Using Ultrasound Shear Wave Elastography in an Adult Asian Indian Population. Indian J Radiol Imaging 2024;34:596–602
32. Congly SE, Shaheen AA, Swain MG. Modelling the cost effectiveness of non-alcoholic fatty liver disease risk stratification strategies in the community setting.

PLoS One. 2021 May 21;16(5):e0251741. doi: 10.1371/journal.pone.0251741. PMID: 34019560; PMCID: PMC8139490.

33. Hiroka N, Hideaki I, Atsushi Uno, Hiroshi N, Hidekatsu K, Masahiro Ogawa, Diagnostic problems in 2 dimensional shear wave elastography of the liver, World journal of RADIOLOGY, 2020 May, 12(5); p 76-86
34. https://bit.ly/SWE-posttraining
35. *Lonardo A, Nascimbeni F, Ballestri S, Fairweather D, Win S, Than TA, Abdelmalek MF, Suzuki A. Sex Differences in Nonalcoholic Fatty Liver Disease: State of the Art and Identification of Research Gaps. Hepatology. 2019 Oct;70(4):1457-1469. doi: 10.1002/hep.30626. Epub 2019 Sep 23. PMID: 30924946; PMCID: PMC6766425*
36. *Yoon, J.S., Lim, K.J. & Hwang, I.T. Usefulness of two-dimensional shear wave elastography in the assessment of non-alcoholic fatty liver disease in children and adolescents. Sci Rep 13, 10062 (2023). https://doi.org/10.1038/s41598-023-37281-z*
37. *in, Y., Feng, X., Cao, X. et al. Age patterns of nonalcoholic fatty liver disease incidence: heterogeneous associations with metabolic changes. Diabetol Metab Syndr 14, 181 (2022). https://doi.org/10.1186/s13098-022-00930-w*
38. *Wu W, Feng A, Ma W, et al. Worldwide long-term trends in the incidence of nonalcoholic fatty liver disease during 1990–2019: a join point and age-period-cohort analysis. Front Cardiovasc Med. 2022;9: 891963.*
39. *Li C, Xing JJ, Shan AQ, Leng L, Liu JC, Yue S, Yu H, Chen X, Tian FS, Tang NJ. Increased risk of nonalcoholic fatty liver disease with occupational stress in Chinese policemen: A 4-year cohort study. Medicine (Baltimore). 2016*

Nov;95(46):e5359. doi: 10.1097/MD.0000000000005359. PMID: 27861366; PMCID: PMC5120923).

40. *Aghakhani L, Haghighat N, Amini M, Hosseini SV, Masoumi SJ. The Risk Factors of Nonalcoholic Fatty Liver Disease in Morbidly Obese Patients Undergoing Bariatric Surgery in Iran. Gastroenterol Res Pract. 2022 Feb 7;2022:5980390. doi: 10.1155/2022/5980390. PMID: 35178085; PMCID: PMC8845117.)*
41. Loomis, A. K., et al , *Body Mass Index and Risk of Nonalcoholic Fatty Liver Disease: Two Electronic Health Record Prospective Studies. The Journal of Clinical Endocrinology & Metabolism, 101(3), 945–952.* doi:10.1210/jc.2015-3444) .
42. *Choi JH, Sohn W, Cho YK. The effect of moderate alcohol drinking in nonalcoholic fatty liver disease. Clin Mol Hepatol. 2020 Oct;26(4):662-669. doi: 10.3350/cmh.2020.0163. Epub 2020 Sep 25. PMID: 32971586; PMCID: PMC7641550.*
43. *Yan-Ci Zhao et al , Nonalcoholic Fatty Liver Disease: An Emerging Driver of Hypertension, Volume 75, Number 2)*
44. *jmera V, Cepin S, Tesfai K, Hofflich H, Cadman K, Lopez S, Madamba E, Bettencourt R, Richards L, Behling C, Sirlin CB, Loomba R. A prospective study on the prevalence of NAFLD, advanced fibrosis, cirrhosis and hepatocellular carcinoma in people with type 2 diabetes. J Hepatol. 2023 Mar;78(3):471-478. doi: 10.1016/j.jhep.2022.11.010. Epub 2022 Nov 19. PMID: 36410554; PMCID: PMC9975077.)*
45. *Mirmiran P, et al . Relationship between Diet and Non-alcoholic Fatty Liver Disease: A Review Article. Iran J Public Health. 2017 Aug;46(8):1007-1017. PMID: 28894701; PMCID: PMC5575379.*

46. Xiong J, Zhang H, Wang Y, Wang A, Bian J, Huang H, Zheng Y, Sang X, Xu Y, Lu X, Zhao H. Hepatitis B virus infection and the risk of nonalcoholic fatty liver disease: a meta-analysis. Oncotarget. 2017 Nov 3;8(63):107295-107302. doi: 10.18632/oncotarget.22364. PMID: 29291029; PMCID: PMC5739814.

47. *Van der Windt DJ, et al , The Effects of Physical Exercise on Fatty Liver Disease. Gene Expr. 2018 May 18;18(2):89-101. doi: 10.3727/105221617X15124844266408. Epub 2017 Dec 6. PMID: 29212576; PMCID: PMC5954622.*

48. *Basaranoglu M, Neuschwander-Tetri BA. Nonalcoholic Fatty Liver Disease: Clinical Features and Pathogenesis. Gastroenterol Hepatol (N Y). 2006 Apr;2(4):282-291. PMID: 28286458; PMCID: PMC5335683.*

49. Hui-Yun Cheng et al , Nonalcoholic Fatty Liver Disease: Prevalence, Influence on Age and Sex, and Relationship with Metabolic Syndrome and Insulin Resistance, International Journal of Gerontology, Volume 7, Issue 4, 2013, Pages 194-198, ISSN 1873-9598, https://doi.org/10.1016/j.ijge.2013.03.008.)

50. *Li YY, Wang XM, Zhang YX, Ou GC. Ultrasonic elastography in clinical quantitative assessment of fatty liver. World J Gastroenterol. 2010;16(37):4733.)*

51. *Yoneda M, Fujita K, Inamori M, Nakajima A, Yoneda M, Tamano M, et al. Transient elastography in patients with non alcoholic fatty liver disease (NAFLD). Gut. 2007;56(9):1330-31.*

52. Patil PV, Julakanti S, Dhadve RU. Point Shear Wave Elastography for Assessment of Liver Stiffness in Normal Individuals and in Patients With Non-alcoholic Fatty Liver Disease. Cureus. 2024 Oct 2;16(10):e70711. doi: 10.7759/cureus.70711. PMID: 39493184; PMCID: PMC11530260

53. BN Vinyasa, Vikram P , Non invasive assessment of fibrosis in Non Alcoholic Fatty Liver Disease by Shear Wave Elastography and NAFLD fibrosis score: A cross sectional study, Journal of clinical and diagnostic research , 2022 Aug, vol-16(8), 06-10

54. Zafar U, Ahmad MN, Nadeem N, Muhammad Zohaib Uddin M, Zafar B, Baig S, Zafar F, Pervez H, Akram S. Correlation of Grades of Non-alcoholic Fatty Liver on Ultrasound with Blood Parameters. Cureus. 2024 Jan 27;16(1):e53075. doi: 10.7759/cureus.53075. PMID: 38414673; PMCID: PMC10896709.

ANNEXURE -1

KAHERs JNMC, BELAGAVI

INFORMED CONSENT FORM

"Assessment of grade of hepatic fibrosis in Non Alcoholic Fatty Liver Disease using Shear Wave Elastography - A One year Hospital based cross sectional study in a tertiary care hospital"

Name of Student/Principal Investigator: BS0122011

Introduction: This is a study on assessment of liver fibrosis in patients with Non Alcoholic Fatty Liver Disease detected by ultrasound using Shear Wave Elastography. Fibrosis if diagnosed early and if preventive and therapeutic measures are taken, it's progression to chronic liver disease, cirrhosis and hepatocellular carcinoma can be prevented.

Explanation of procedure: In this study, the patients visiting Radiology Department of KLE's Dr. Prabhakar Kore Hospital & Medical Research Centre, Belagavi who are detected to have fatty liver on ultrasonography will be subjected to Shear wave Elastography to know the amount of liver stiffness. Also they will be questioned to find out if they have any known factors.

Withdrawal from participation in the study: Participation in this study is voluntary. You will be free to decide whether to participate in this study or continue participation once enrolled. In case you decide to withdraw your participation, you are free to do so. However, please convey the decision to the principal investigator.

Possible benefits from participating in the study: You will be benefited by participating in this study as you will get to know the amount of fibrosis in your liver and thus with lifestyle modifications and medications you will be able to hault the disease progression. Also, the data gathered will help the population at large.

Possible risks from participating in the study: There are no risks involved in participating in this study.

Privacy and confidentiality: The information collected from you will be coded, to prevent any person from identifying you. Your identity will never be revealed. The data collected from you will be kept confidential and only processed or aggregated data will be used for publication.

Financial incentives: You will not receive any payment for participating in this study. Cost of investigations done during the course of study will be paid by the principal investigator.

Authorization for storage and publication of aggregated data: Results obtained after processing of the aggregated data will be stored and published for scientific purpose and or presented to scientific groups. However, your identity will never be revealed.

Legal rights: By signing this consent form, we are not waving any of your legal rights

CONSENT STATEMENT

I am making a voluntary decision to participate in the study "Assessment of grade of hepatic fibrosis in Non Alcoholic Fatty Liver Disease using Shear Wave Elastography - A One year Hospital based cross sectional study in a tertiary care hospital".

My signature below indicates that I have decided to participate and I have read the information provided above or the information provided above has been read to me in the language that I understand best. I was given the opportunity to ask questions and that they have been answered to my satisfaction.

Name of the participant:

Signature or left thumb impression of the participant:

Name of the witness:

Signature or left thumb impression of the witness:

Name of the investigator:

Signature of the investigator

ANNEXURE -2

PROFORMA

Assessment of grade of hepatic fibrosis in Non Alcoholic Fatty Liver Disease using Shear Wave Elastography - A One year Hospital based cross sectional study in a tertiary care hospital

Questionnaire

A) Biodata

1. Name- 2. Age - 3. Sex-

4. Phone number- 5. Occupation-

6. Address-

7. Height- 8. Weight -

B) RISK FACTORS (Table no 16)-

1. Alcohol	6. Hepatitis
2. BMI	7. History of blood transfusion
3. Diabetes	8. Family history of liver disease
4. Hypertensive disorder	9. Regular exercise
5. Drugs	10.Dietary habits(vegetarian/mixed diet/high intake of saturated fat)

C) USG Findings-

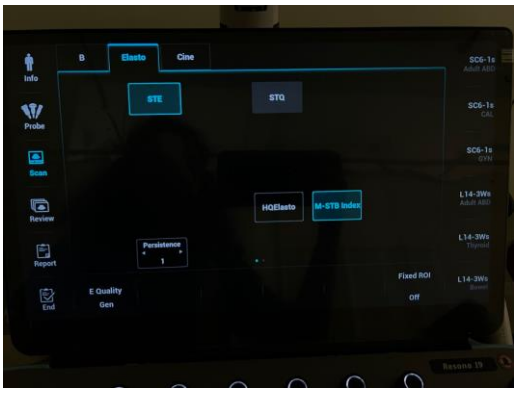
D) Elastography Findings-

ANNEXURE -3

FIGURES AND PHOTOGRAPHS OF THE CASES

Ultrasonography machine (Figure no 13)

Curvilinear probe SC6-1s(Figure no 14)



Elastography feature of the Mindray Resona i9 ultrasound machine (Figure no 15 and 16)

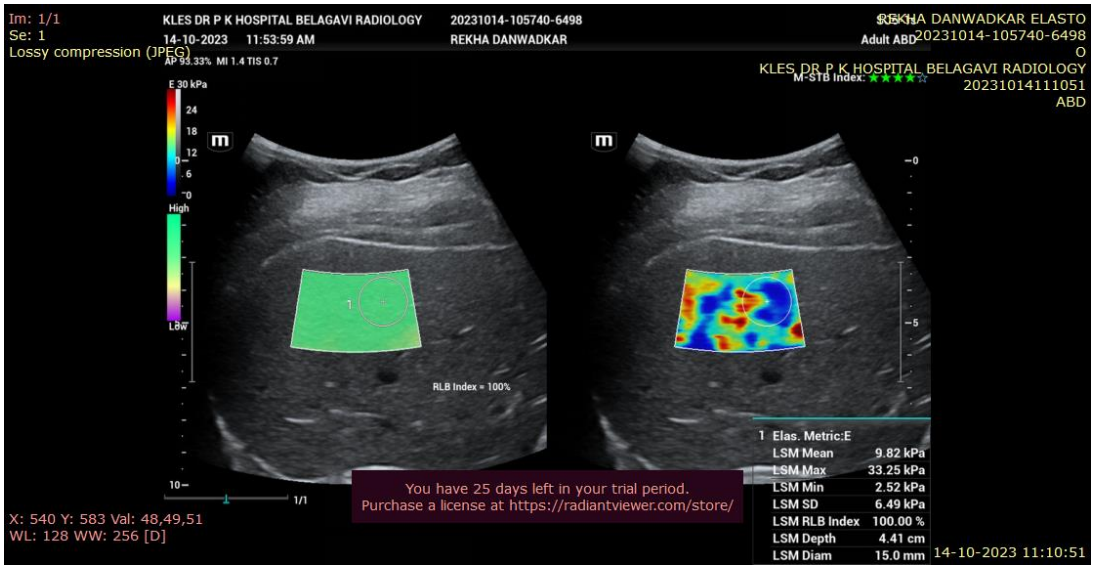
Case I : 45 year old female , cook by profession with a BMI of 33.8 kg/m^2

Came to the opd for routine check-up and was adviced USG abdomen and pelvis . (Figures no 17 and 18)

Gray scale ultrasound:

(There is increase in the echogenicity if the liver parenchyma however the periportal echogenicities are preserved suggestive of Grade I fatty infiltration)

Shear wave elastography :



(Circle is placed in the ROI box in homogenous colour area and 5-6 values were

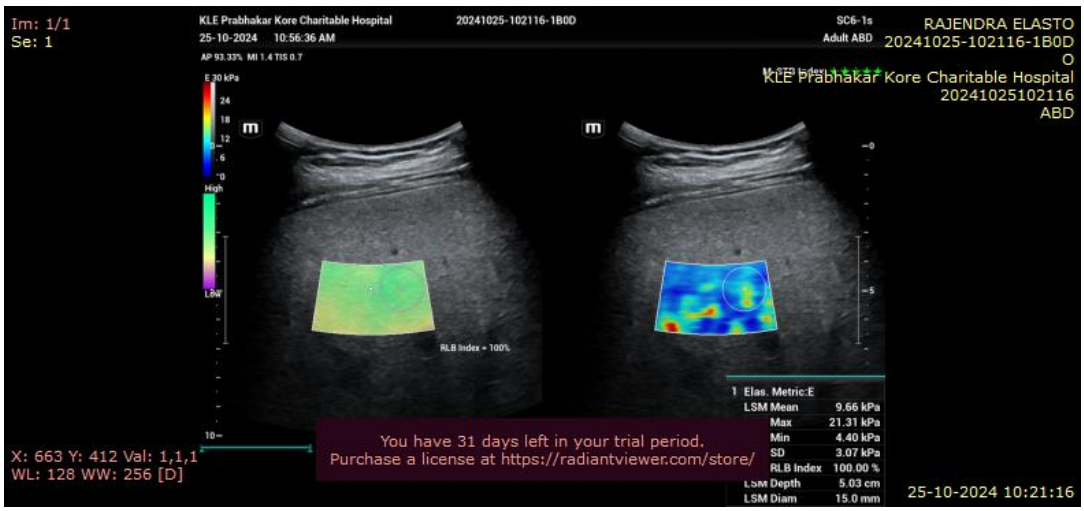
recorded and mean kPa values considered)

Case 2: 48 year old male , pharmacist by occupation came to the opd for complaint of acidity and upper gastrointestinal discomfort. The patient was adviced USG abdomen and pelvis. (Figures no 19 and 20).

Gray scale ultrasound:

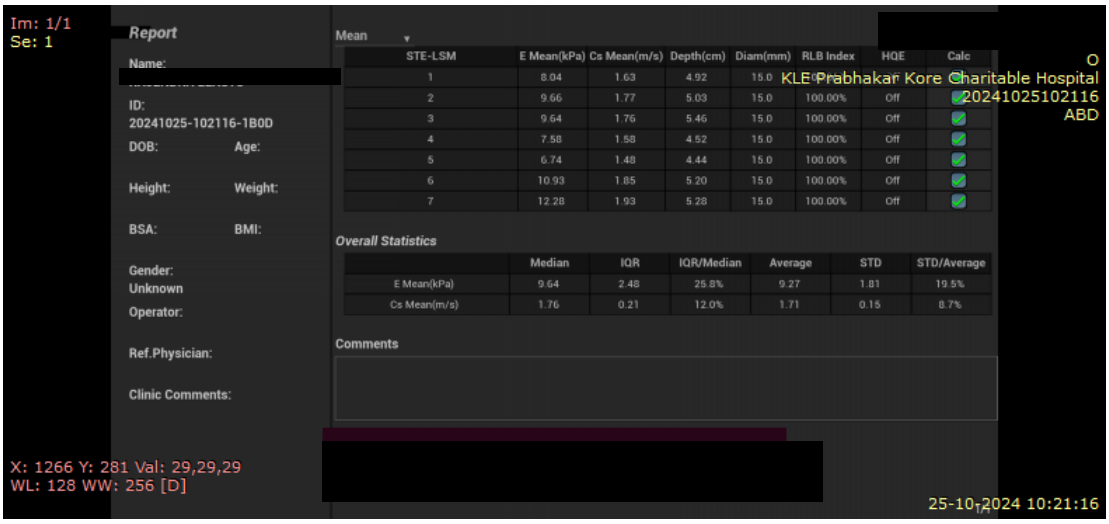
(There is increase in the echogenicity if the liver parenchyma with loss of periportal echogenicities are preserved suggestive of Grade I fatty infiltration)

Shear wave elastography :



(Circle is placed in the ROI box in homogenous colour area and 5-6 values were recorded and mean kPa values considered)

(Figure no 21: System generated report of shear wave elastography)



Five or more high quality acquisitions are obtained with an interquartile range-to-median ratio (IQR/M) <30%, the median value in kPa is recorded. The median value of elastography is interpreted using the cut offs and graded into 5 grades.

Cutoffs used to grade the liver stiffness on elastography (Table no 17):

Parameter	*N* (%) 95% CI	Interpretation
<5 kPa	56 (6.57%) 5.10, 8.44	High probability of being normal
<9 kPa	496 (58.22%) 54.87, 61.48	In the absence of other clinical signs, rules out cACLD. Needs further tests based on clinical signs
9–13 kPa	200 (23.47%) 20.75, 26.44	Suggestive of cACLD but needs further evaluation
>13 kPa	58 (6.81%) 5.30, 8.7	Rules in cACLD
>17 kPa	42 (4.91%) 3.67, 6.60	Suggestive of CSPH

ANNEXURE -4

Master chart

Sr no.	Age	Sex	Occupation	Height	Weight	BMI	Alcohol	HTN	Hepatitis	History of blood transfusion	Family history of liver disease	Regular exercise	Dietary habits	Lipid profile	Grade of fatty liver	Hepatomegaly	Elastography findings	SWE grading
1	54	F	Housewife	148	88	41	N	No	No	No	No	No	Vegetarian	Not Available	1	present	8.68	G1
2	62	M	Framer	163	67	25	N	Yes	No	No	No	No	Mixed diet	Not Available	2	absent	9.74	G2
3	62	M	Ex Army servicemen	155	73	30	Y	Yes	No	No	No	Yes	Mixed diet	Not Available	1	absent	8.6	G1
4	60	F	Housewife	151	60	26	N	Yes	No	No	No	No	Mixed diet	Not Available	2	absent	7.5	G1
5	35	F	Housewife	152	59	26	N	No	No	Yes	No	Yes	Mixed diet	Not Available	1	absent	6.56	G1
6	80	M	Farmer	159	70	24	N	No	No	No	No	No	Mixed diet	Not Available	3	absent	10.7	G2
7	49	M	Gas factory worker	157	54	23	N	No	No	No	No	No	Mixed diet	Not Available	1	absent	4	G0
8	43	F	Housewife	135	46	25	N	No	No	Yes	No	No	Mixed diet	Not Available	1	absent	8.9	G1
9	45	F	Cook	147	71	34	N	No	No	No	No	No	Mixed diet	Not Available	1	absent	11.9	G2
10	46	M	Road traffic officer	170	74	26	N	No	No	No	No	Yes	Vegetarian	Cholesterol- 206, trig- 248, chol/hdl-5.7	1	absent	6	G1
11	43	F	Housewife	155	78	34	N	No	No	No	No	Yes	Mixed diet	Not Available	1	present	9.2	G2
12	38	F	Farmer	154	65	27	N	No	No	Yes	No	No	Vegetarian	Not Available	1	absent	6.7	G1
13	59	F	Housewife	153	52	23	N	No	No	No	No	No	Mixed diet	Not Available	1	absent	5.58	G1
14	42	M	Air Force	165	69	26	N	No	Yes	No	No	Yes	Mixed diet	Not Available	1	absent	6.8	G1
15	64	M	Nuclear power plant retired	163	83	32	Y	Yes	No	No	No	No	Mixed diet	Not Available	1	absent	4.2	G0
16	31	F	Housewife	157	66	27	N	No	No	No	No	No	Mixed diet	Not Available	1	absent	7.45	G1
17	32	M	Labour	155	62	26	N	No	No	No	No	No	Mixed diet	Not Available	1	absent	7.78	G1
18	37	F	Clerk	163	62	24	N	No	No	No	No	Yes	Mixed diet	Not Available	1	absent	7.46	G1
19	49	M	Clerk	157	69	28	N	No	No	No	No	Yes	Vegetarian	Not Available	1	absent	9.25	G2
20	54	F	Housewife	155	75	31	N	Yes	No	No	No	Yes	Mixed diet	Not Available	1	absent	7.33	G1

21	31	M	Security gaurd	160	90	35	N	No	No	No	No	No	Mixed diet	Not Available	2	present	7.8	G1
22	40	M	Retired army man	172	85	29	N	No	No	No	No	Yes	Mixed diet	Not Available	1	present	6.3	G1
23	68	M	Retired	170	98	34	N	Yes	No	No	No	No	Mixed diet	Not Available	2	absent	7.3	G1
24	51	M	Ex army man	167	71	26	Y	Yes	No	No	No	Yes	Mixed diet	Not Available	1	present	12.5	G2
25	66	M	Retired army man	155	63	26	N	Yes	No	No	No	Yes	Mixed diet	Not Available	1	absent	7.3	G1
26	55	F	Housewife	154	71	30	N	No	No	No	No	Yes	Mixed diet	Not Available	1	present	8	G2
27	36	M	Journalist	168	64	23	N	No	No	No	No	No	Mixed diet	Not Available	1	absent	7.8	G1
28	54	M	ARSA	156	90	38	N	No	No	No	No	Yes	Mixed diet	Not Available	2	absent	9.2	G2
29	31	F	Nurse	160	63	25	N	No	No	No	No	Yes	Mixed diet	Not Available	1	absent	6.9	G1
30	54	M	Ex serviceman	171	78	24	Y	Yes	No	No	No	No	Mixed diet	Cholesterol- 167 , Trig- 313, hdl-45,ldl- 84	1	absent	7.6	G1
31	33	M	Jail warden	179	85	27	N	No	No	No	No	Yes	Mixed diet	Not Available	2	absent	5.7	G1
32	35	M	Police officer	170	73	26	N	No	No	No	No	Yes	Mixed diet	Not Available	1	absent	7.1	G1
33	38	M	Private company employee	179	102	35	N	Yes	No	No	No	No	Vegetarian	Not Available	2	present	7.6	G1
34	40	M	Police	172	88	31	N	No	No	No	No	No	Vegetarian	Not Available	2	absent	10.9	G2
35	48	M	Police officer	170	91	33	N	No	No	No	No	No	Mixed diet	Not Available	1	absent	10.8	G2
36	51	M	Lawyer	155	68	28	N	Yes	No	No	No	Yes	Mixed diet	Not Available	1	absent	7.8	G1
37	61	F	Housewife	154	85	36	N	Yes	No	Yes		No	Vegetarian	Not Available	2	absent	7	G1
38	68	M	Farmer	156	65	27	Y	Yes	No	No	No	No	Mixed diet	Not Available	2	absent	6.2	G1
39	60	F	Housewife	157	62	24	N	No	No	No	No	No	Mixed diet	Not Available	2	present	8.2	G1
40	67	F	Housewife	151	70	31	N	Yes	No	No	No	No	Mixed diet	Not Available	2	present	11.4	G2
41	28	F	Tailor	157.5	74	29	N	Yes	No	No	No	Yes	Vegetarian	Not Available	1	absent	5.5	G1
42	49	F	Housewife	150	59	26	N	Yes	No	No	No	No	Mixed diet	Not Available	1	absent	11	G2
43	50	M	Farmer	157	65	26	N	No	No	No	No	No	Mixed diet	Not Available	2	absent	7.9	G1
44	33	M	Unemployed	154	55	23	N	No	No	Yes	No	No	High consumption of saturated fats	Not Available	2	present	8.2	G2
45	67	F	Farmer	152	85	37	N	Yes	No	Yes	No	No	Vegetarian	Not Available	2	present	10.1	G2
46	46	M	Auto driver	150	61	27	Y	No	No	No	No	Yes	Mixed diet	Not Available	1	absent	6.3	G1
47	48	F	Coolie	152	70	30	N	No	No	No	No	No	Mixed diet	Not Available	1	present	7.6	G1
48	55	F	Housewife	154	70	30	N	Yes	No	No	No	Yes	Mixed diet	Not Available	1	present	7.1	G1
49	77	F	Housewife	152	53	23	N	No	No	No	No	Yes	Vegetarian	Not Available	1	absent	6.7	G1
50	30	F	Housewife	153	68	30	N	No	No	No	No	No	Mixed diet	Not Available	1	present	7.2	G1
51	67	M	Farmer	157	64	26	Y	Yes	No	No	No	Yes	Vegetarian	Not Available	1	absent	7.6	G1
52	61	F	Housewife	148	65	30	N	Yes	No	No	No	No	Mixed diet	Not Available	1	absent	7.7	G1
53	41	M	Pharmacist	170	78	27	Y	No	No	No	No	Yes	Mixed diet	Not Available	2	present	9.6	G2