Elastography of the Liver

Giovanna Ferraioli

Ultrasound Unit - Infectious Diseases Dept.
Fondazione IRCCS Policlinico S. Matteo
Medical School, University of Pavia, Italy

Disclosure

Philips Ultrasound, travel fee
Loan of equipment for research purposes:
- Ultrasound system Aixplorer, Supersonic Imagine S.A., Aix-en-Provence, France
- Ultrasound system Acuson S2000, Siemens Healthcare, Erlangen, Germany
- Ultrasound system Ascendus, Hitachi Aloka Medical System, Tokyo, Japan
- Ultrasound system Twice, Esaote SpA, Genoa, Italy
- Ultrasound system iU22, Philips Medical Systems, Bothell, WA, USA
- Fibroscan, Echosens, Paris, France

Chronic Liver Diseases

- In chronic liver diseases the prognosis and management largely depend on the extent and progression of liver fibrosis.
- In patients with chronic hepatitis C fibrosis is the most important predictor of outcome and influences the indication for antiviral treatment.
- Recent works suggest that liver fibrosis may be modified by treatment.

Liver Biopsy

Low mortality (0.01-0.17%)
Relative low morbidity (5.9%)

Recommended specimen:
- Length > 15-25 mm
- Portal spaces > 10

Correct diagnosis:
- 65% specimens > 15 mm
- 75% specimens > 25 mm

Histologic Scoring Systems

Metavir (0,1,2,3,4)
Ishak (0,1,2,3,4,5,6)
Scheuer (0,1,2,3,4)
Knodell (0,1,3,4)

MEtAVIR Scoring System

F0, no fibrosis
F1, portal fibrosis without septa
F2, few septa
F3, many septa without cirrhosis
F4, cirrhosis

Images: courtesy Barbara Dal Bello, MD

Farrell R J et al. J Hepatol 1999
Colloredo G et al. J Hepatol 2003
Limitations of Liver Biopsy

- Invasive procedure
- Poor patient compliance
- Risk of complications
- Diagnostic accuracy of scoring systems is affected by intra- and interobserver variability in the assessment of fibrosis stage
- Not an ideal procedure for repeated assessment of disease progression
- Costs

Non-Invasive Assessment of Liver Fibrosis

Transient Elastography (FibroScan)

Elastic Waves Propagation with Different Fibrosis Stages

The slope of the white dotted lines represents the propagation velocity of the wave pattern that increases as a function of fibrosis staging.


Reproducibility

TE reproducibility has been shown excellent for both inter-observer and intra-observer agreement, with intraclass correlation coefficients (ICC) of 0.98.

Interobserver agreement is reduced in patients with:

- Lower degrees of hepatic fibrosis;
- Hepatic steatosis;
- Increased BMI.

Fraquelli M et al. Gut 2007

Values of TE

Normal subjects

5.5±1.6 kPa

Subjects with chronic viral hepatitis

Results

Several studies and meta-analyses have shown that TE is an accurate method in staging liver fibrosis.

In treatment-naïve patients with chronic hepatitis C without co-morbidities the use of TE has been endorsed by the EASL Clinical Practice Guidelines. (GRADE system, Evidence A2)

### Performance of Liver Stiffness Measurements by Transient Elastography in Chronic Hepatitis

<table>
<thead>
<tr>
<th>F</th>
<th>Sensitivity %</th>
<th>Specificity %</th>
<th>PPV %</th>
<th>NPV %</th>
<th>LR+</th>
<th>LR-</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>F &gt; 2</td>
<td>69.1 (58.9-78.1)</td>
<td>89.8 (82.0-95.0)</td>
<td>87.0 (77.4-93.6)</td>
<td>74.6 (65.7-82.1)</td>
<td>6.8</td>
<td>0.3</td>
<td>0.86</td>
</tr>
<tr>
<td>&gt; 7.0 kPa</td>
<td>70 (66-75)</td>
<td>81 (77-85)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F &gt; 3</td>
<td>94.1 (83.8-98.8)</td>
<td>85.4 (70.6-90.7)</td>
<td>69.6 (57.3-80.1)</td>
<td>97.6 (93.2-99.4)</td>
<td>6.5</td>
<td>0.07</td>
<td>0.95</td>
</tr>
<tr>
<td>&gt; 9.3 kPa*</td>
<td>74.5 (60.4-85.7)</td>
<td>96.5 (92.1-98.9)</td>
<td>88.4 (74.9-96.1)</td>
<td>91.4 (85.8-95.4)</td>
<td>21.5</td>
<td>0.3</td>
<td>0.86</td>
</tr>
<tr>
<td>&gt; 9.5 kPa</td>
<td>80 (72-88)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F = 4</td>
<td>93.8 (79.2-99.2)</td>
<td>92.0 (86.7-95.7)</td>
<td>69.0 (53.9-82.8)</td>
<td>98.7 (93.3-99.8)</td>
<td>11.8</td>
<td>0.07</td>
<td>0.97</td>
</tr>
<tr>
<td>&gt; 12.3 kPa*</td>
<td>61.3 (46.6-76.1)</td>
<td>95.7 (91.4-98.3)</td>
<td>78.0 (61.1-91.0)</td>
<td>96.0 (92.1-98.6)</td>
<td>18.9</td>
<td>0.2</td>
<td>0.97</td>
</tr>
<tr>
<td>&gt; 12 kPa</td>
<td>86 (78-94)</td>
<td>88 (82-91)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* *F* is the stage of liver fibrosis according to the METAVIR system.

### Limitations

- Obese patients;
- Narrow intercostal space;
- TE cannot be performed in patients with perihepatic ascites.

Failures reported in up to 4% of examinations

Unreliable results in up to 17% of examinations

Both were associated with obesity or limited operator experience.

A new probe (XL) has been proposed for overweight and obese patients. The median liver stiffness values are lower using the XL probe.

### Advantages of US Elastography

- Liver stiffness measurements are guided by the B-mode image;
- The operator can search for an acoustic window in real-time;
- The same ultrasound system is used for both US imaging and elastography.

---

**Results**

Several studies and meta-analyses have shown that TE is an accurate method in staging liver fibrosis.

In treatment-naïve patients with chronic hepatitis C without co-morbidities the use of TE has been endorsed by the EASL Clinical Practice Guidelines. (GRADE system, Evidence A2)

### Performance of Liver Stiffness Measurements by Transient Elastography in Chronic Hepatitis

<table>
<thead>
<tr>
<th>F</th>
<th>Sensitivity %</th>
<th>Specificity %</th>
<th>PPV %</th>
<th>NPV %</th>
<th>LR+</th>
<th>LR-</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>F &gt; 2</td>
<td>69.1 (58.9-78.1)</td>
<td>89.8 (82.0-95.0)</td>
<td>87.0 (77.4-93.6)</td>
<td>74.6 (65.7-82.1)</td>
<td>6.8</td>
<td>0.3</td>
<td>0.86</td>
</tr>
<tr>
<td>&gt; 7.0 kPa</td>
<td>70 (66-75)</td>
<td>81 (77-85)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F &gt; 3</td>
<td>94.1 (83.8-98.8)</td>
<td>85.4 (70.6-90.7)</td>
<td>69.6 (57.3-80.1)</td>
<td>97.6 (93.2-99.4)</td>
<td>6.5</td>
<td>0.07</td>
<td>0.95</td>
</tr>
<tr>
<td>&gt; 9.3 kPa*</td>
<td>74.5 (60.4-85.7)</td>
<td>96.5 (92.1-98.9)</td>
<td>88.4 (74.9-96.1)</td>
<td>91.4 (85.8-95.4)</td>
<td>21.5</td>
<td>0.3</td>
<td>0.86</td>
</tr>
<tr>
<td>&gt; 9.5 kPa</td>
<td>80 (72-88)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F = 4</td>
<td>93.8 (79.2-99.2)</td>
<td>92.0 (86.7-95.7)</td>
<td>69.0 (53.9-82.8)</td>
<td>98.7 (93.3-99.8)</td>
<td>11.8</td>
<td>0.07</td>
<td>0.97</td>
</tr>
<tr>
<td>&gt; 12.3 kPa*</td>
<td>61.3 (46.6-76.1)</td>
<td>95.7 (91.4-98.3)</td>
<td>78.0 (61.1-91.0)</td>
<td>96.0 (92.1-98.6)</td>
<td>18.9</td>
<td>0.2</td>
<td>0.97</td>
</tr>
<tr>
<td>&gt; 12 kPa</td>
<td>86 (78-94)</td>
<td>88 (82-91)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* *F* is the stage of liver fibrosis according to the METAVIR system.

### Limitations

- Obese patients;
- Narrow intercostal space;
- TE cannot be performed in patients with perihepatic ascites.

Failures reported in up to 4% of examinations

Unreliable results in up to 17% of examinations

Both were associated with obesity or limited operator experience.

A new probe (XL) has been proposed for overweight and obese patients. The median liver stiffness values are lower using the XL probe.

### Advantages of US Elastography

- Liver stiffness measurements are guided by the B-mode image;
- The operator can search for an acoustic window in real-time;
- The same ultrasound system is used for both US imaging and elastography.

---

**Results**

Several studies and meta-analyses have shown that TE is an accurate method in staging liver fibrosis.

In treatment-naïve patients with chronic hepatitis C without co-morbidities the use of TE has been endorsed by the EASL Clinical Practice Guidelines. (GRADE system, Evidence A2)

### Performance of Liver Stiffness Measurements by Transient Elastography in Chronic Hepatitis

<table>
<thead>
<tr>
<th>F</th>
<th>Sensitivity %</th>
<th>Specificity %</th>
<th>PPV %</th>
<th>NPV %</th>
<th>LR+</th>
<th>LR-</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>F &gt; 2</td>
<td>69.1 (58.9-78.1)</td>
<td>89.8 (82.0-95.0)</td>
<td>87.0 (77.4-93.6)</td>
<td>74.6 (65.7-82.1)</td>
<td>6.8</td>
<td>0.3</td>
<td>0.86</td>
</tr>
<tr>
<td>&gt; 7.0 kPa</td>
<td>70 (66-75)</td>
<td>81 (77-85)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F &gt; 3</td>
<td>94.1 (83.8-98.8)</td>
<td>85.4 (70.6-90.7)</td>
<td>69.6 (57.3-80.1)</td>
<td>97.6 (93.2-99.4)</td>
<td>6.5</td>
<td>0.07</td>
<td>0.95</td>
</tr>
<tr>
<td>&gt; 9.3 kPa*</td>
<td>74.5 (60.4-85.7)</td>
<td>96.5 (92.1-98.9)</td>
<td>88.4 (74.9-96.1)</td>
<td>91.4 (85.8-95.4)</td>
<td>21.5</td>
<td>0.3</td>
<td>0.86</td>
</tr>
<tr>
<td>&gt; 9.5 kPa</td>
<td>80 (72-88)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F = 4</td>
<td>93.8 (79.2-99.2)</td>
<td>92.0 (86.7-95.7)</td>
<td>69.0 (53.9-82.8)</td>
<td>98.7 (93.3-99.8)</td>
<td>11.8</td>
<td>0.07</td>
<td>0.97</td>
</tr>
<tr>
<td>&gt; 12.3 kPa*</td>
<td>61.3 (46.6-76.1)</td>
<td>95.7 (91.4-98.3)</td>
<td>78.0 (61.1-91.0)</td>
<td>96.0 (92.1-98.6)</td>
<td>18.9</td>
<td>0.2</td>
<td>0.97</td>
</tr>
<tr>
<td>&gt; 12 kPa</td>
<td>86 (78-94)</td>
<td>88 (82-91)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* *F* is the stage of liver fibrosis according to the METAVIR system.

### Limitations

- Obese patients;
- Narrow intercostal space;
- TE cannot be performed in patients with perihepatic ascites.

Failures reported in up to 4% of examinations

Unreliable results in up to 17% of examinations

Both were associated with obesity or limited operator experience.

A new probe (XL) has been proposed for overweight and obese patients. The median liver stiffness values are lower using the XL probe.

### Advantages of US Elastography

- Liver stiffness measurements are guided by the B-mode image;
- The operator can search for an acoustic window in real-time;
- The same ultrasound system is used for both US imaging and elastography.
**Procedure**

- Fasting conditions;
- Dorsal decubitus positioning, with the right arm elevated above the head for optimal intercostal access;
- Resting respiratory position (breath-hold without deep inspiration);
- Minimal scanning pressure applied by the operator;
- ROI placement beneath Glisson’s capsule by 1.5-2.0 cm to avoid reverberation artifacts;
- ROI placement to avoid large liver vessels.

*General procedures, valid for all techniques

---

**Point Shear Wave Elastography**

---

**VTTQ® (Siemens Healthcare)**

**Reproducibility**

**ICC: 0.84 - 0.87**

- Boursier J et al. Eur J Gastroenterol Hepatol 2010
- D’Onofrio M et al. AJR Am J Roentgenol 2010

---

**Comparison of Transient Elastography and Acoustic Radiation Force Impulse for Non-Invasive Staging of Liver Fibrosis in Patients with Chronic Hepatitis C**

139 consecutive patients with CHC were enrolled in two tertiary centers

**ARFI best cutoff values:**

- Significant fibrosis (F2) ≥ 1.3 m/s (AUROC: 0.86)
- Severe fibrosis (F3-F4) ≥ 1.7 m/s (AUROC: 0.94)
- Cirrhosis (F=4) ≥ 2.0 m/s (AUROC: 0.89)

**ARFI performance results significantly higher than TE for all three stages of fibrosis.**

The average concordance rates of TE and ARFI with liver biopsy were 45.4% and 54.7%.

Rizzo L et al. Am J Gastroenterol 2011
Acoustic radiation force impulse elastography shows higher rate of reliable measurements and similar predictive value to TE for significant fibrosis and cirrhosis.

Bota S et al. Liver Int 2013

13 studies including 1163 patients with chronic liver disease

Meta-analysis: ARFI Elastography Versus Transient Elastography for the Evaluation of Liver Fibrosis

ElastPQ® (Philips Healthcare)

ElastPQ Reproducibility

- Healthy volunteers and patients with chronic liver disease
- Number of observations: 106
- Median value of stiffness in healthy volunteers: 3.5 kPa (IQR, 3.2-4.0)

Inter-Observer Agreement: Concordance Correlation Coefficient 0.97 (95% CI, 0.96-0.98)

Ferraioli G et al. World J Gastroenterol 2014

Assessment of Impact Factors on Shear Wave Based Liver Stiffness Measurement

Liver stiffness was 8% higher in men than in women (3.8 ± 0.7 kPa vs. 3.5 ± 0.4 kPa, P = 0.02)

Liver stiffness was comparable in different age groups

Ling W et al. Eur J Radial 2013

A Point Shear Wave Elastography Method for Assessing Liver Stiffness

Group1: Consecutive pts. with chronic liver disease scheduled for liver biopsy
Group2: Healthy volunteers

- PSWE with the iU22 ultrasound system (Philips Medical Systems, Bothell, WA, USA) with a convex broadband probe and ElastPQ technique
- Transient Elastography (TE) with the FibroScan device (Echosens, Paris, France).

In Group 1 ultrasound-assisted liver biopsy was performed in the same day.

Ferraioli G et al. World J Gastroenterol 2014

Results

Total: 203 consecutive subjects (140 males and 63 females)

Group1 Chronic liver disease
- 134 subjects
- Males 105 (76.6%)
- Females 29 (23.4%)
- Age 43.7 (SD: 11.4)
- BMI 25.1 (SD: 4.5)
- Failures TE: 1 PSWE: 5

Group2 Healthy volunteers
- 69 subjects
- Males 35 (50.7%)
- Females 34 (49.3%)
- Age 38.9 (SD: 13.8)
- BMI 23.0 (SD: 4.9)
- Failures TE: 0 PSWE: 0
**Results:**

**HCV Hepatitis**

102 patients

<table>
<thead>
<tr>
<th>Fibrosis score (METAVIR)</th>
<th>n=101</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>82 (78.7%)</td>
</tr>
<tr>
<td>Females</td>
<td>20 (21.3%)</td>
</tr>
<tr>
<td>Age</td>
<td>45.2 (SD:11.0)</td>
</tr>
<tr>
<td>BMI</td>
<td>25.2 (SD:4.9)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fibrosis score (METAVIR)</th>
<th>n=101</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0</td>
<td>6 (5.9%)</td>
</tr>
<tr>
<td>F1</td>
<td>44 (43.6%)</td>
</tr>
<tr>
<td>F2</td>
<td>24 (23.8%)</td>
</tr>
<tr>
<td>F3</td>
<td>17 (16.8%)</td>
</tr>
<tr>
<td>F4</td>
<td>10 (9.9%)</td>
</tr>
</tbody>
</table>

**Median Values of TE and PSWE**

**ROC Curves**

- **F>2**
- **F>3**
- **F=4**

**2D Shear Wave Elastography**

SWE (SuperSonic Imagine S.A.)
Reproducibility of Real-Time Shear Wave Elastography in the Evaluation of Liver Elasticity

<table>
<thead>
<tr>
<th></th>
<th>Intra-Observer Agreement</th>
<th>Inter-Observer Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
<td>0.95 (95% CI, 0.93-0.98)</td>
<td></td>
</tr>
<tr>
<td>Novice</td>
<td>0.93 (95% CI, 0.90-0.96)</td>
<td>0.88 (95% CI, 0.83-0.94)</td>
</tr>
</tbody>
</table>


Intra-Observer Agreement

Expert

Novice

0.95 (95% CI, 0.93-0.98)

0.88 (95% CI, 0.83-0.94)

Between days

Inter-Observer Agreement

Expert

Novice

0.84 (95% CI, 0.69-0.98)

0.65 (95% CI, 0.39-0.91)

Accuracy of Real-Time Shear Wave Elastography for Assessing Liver Fibrosis in Chronic Hepatitis C: a Pilot Study

121 patients with chronic hepatitis C

Males: n=87
Females: n=34
Age: 45y
BMI: 25.4 Kg/m²

Ultrasound system Aixplorer (SuperSonic Imagine S.A., Aix-en-Provence, France) with a convex broadband probe.

Ferraioli G et al. Hepatology 2013

Median Values for Each METAVIR Fibrosis Stage

Fibrosis  Stage

F0-F1 50 (41%)

F2 33 (27%)

F3 14 (12%)

F4 24 (20%)

Limitations

- Cut-off values are system-specific and cannot readily be compared across machines.
- The majority of the studies were performed in patients with chronic hepatitis C, thus the cutoffs are not applicable to other viral etiologies and to NAFLD.
- Only small series of patients with NAFLD have been studied, thus the cutoffs in these patients need to be validated.

Accuracy of Real-Time Shear Wave Elastography for Assessing Liver Fibrosis in Chronic Hepatitis C: a Pilot Study

F0-F1 50 (41%)

F2 33 (27%)

F3 14 (12%)

F4 24 (20%)

121 patients with chronic hepatitis C

Males: n=87
Females: n=34
Age: 45y
BMI: 25.4 Kg/m²

Ultrasound system Aixplorer (SuperSonic Imagine S.A., Aix-en-Provence, France) with a convex broadband probe.

Ferraioli G et al. Hepatology 2013

Median Values for Each METAVIR Fibrosis Stage

Fibrosis  Stage

F0-F1 50 (41%)

F2 33 (27%)

F3 14 (12%)

F4 24 (20%)

Limitations

- Cut-off values are system-specific and cannot readily be compared across machines.
- The majority of the studies were performed in patients with chronic hepatitis C, thus the cutoffs are not applicable to other viral etiologies and to NAFLD.
- Only small series of patients with NAFLD have been studied, thus the cutoffs in these patients need to be validated.

Accuracy of Real-Time Shear Wave Elastography for Assessing Liver Fibrosis in Chronic Hepatitis C: a Pilot Study

F0-F1 50 (41%)

F2 33 (27%)

F3 14 (12%)

F4 24 (20%)

121 patients with chronic hepatitis C

Males: n=87
Females: n=34
Age: 45y
BMI: 25.4 Kg/m²

Ultrasound system Aixplorer (SuperSonic Imagine S.A., Aix-en-Provence, France) with a convex broadband probe.

Ferraioli G et al. Hepatology 2013

Median Values for Each METAVIR Fibrosis Stage

Fibrosis  Stage

F0-F1 50 (41%)

F2 33 (27%)

F3 14 (12%)

F4 24 (20%)

Limitations

- Cut-off values are system-specific and cannot readily be compared across machines.
- The majority of the studies were performed in patients with chronic hepatitis C, thus the cutoffs are not applicable to other viral etiologies and to NAFLD.
- Only small series of patients with NAFLD have been studied, thus the cutoffs in these patients need to be validated.
Exacerbations of acute hepatitis associated with transaminase flares, thus the effect of necro-inflammation should be taken into account, and the results should always be evaluated in clinical settings; Congestive heart failure; Feeding; Extrahepatic cholestasis; Deep inspiration, so that transiently stopping breathing in a neutral position is optimal for measurements.

Confounder Factors

Stiffness increases with:

- Exacerbations of acute hepatitis associated with transaminase flares, thus the effect of necro-inflammation should be taken into account, and the results should always be evaluated in clinical settings;
- Congestive heart failure;
- Feeding;
- Extrahepatic cholestasis;
- Deep inspiration, so that transiently stopping breathing in a neutral position is optimal for measurements.

Accuracy of Liver Elastography

- In the assessment of significant fibrosis all shear wave based elastography methods show a high level of accuracy;
- Current evidence suggest that these methods could be used in patients with chronic hepatitis C to assess liver disease severity before therapy at a safe level of predictability.

Fibrosis Assessment

Guidelines

EASL Clinical Practice Guidelines: Management of hepatitis C virus infection. J Hepatol 2014

Fibrosis stage can be assessed by non-invasive methods initially, with liver biopsy reserved for cases where there is uncertainty or potential additional etiologies (recommendation B1)

An update on the management of chronic hepatitis C: Consensus guidelines from the Canadian Association for the Study of the Liver. Can J Gastroenterol 2012

All patients with HCV should undergo an assessment for the severity of liver fibrosis. Acceptable methods include liver biopsy, elastography (eg, FibroScan) and serum biomarker panels (eg, AST/platelet ratio index, FibroTest, FibroMeter), either alone or in combination (Class 2a, Level B).

In England, the National Institute for Health and Care Excellence recommends:

- To offer antiviral treatment without a liver biopsy to adults with a TE score ≥ 11 kPa;
- To not offer liver biopsy to adults with a TE < 6 kPa who have normal ALT and HBV DNA less than 2000 IU/ml as they are unlikely to have advanced liver disease or need antiviral treatment;
- To offer an annual reassessment of liver disease using TE to adults who are not taking antiviral treatment.

Diagnosis and Management of Chronic Hepatitis B in Children, Young People, and Adults: Summary of NICE Guidance

Detection of Early Portal Hypertension with Routine Data and Liver Stiffness in Patients with Asymptomatic Liver Disease: A Prospective Study

250 consecutive patients

Group A, platelets >150,000/mm³, normal abdominal ultrasound;
Group B, platelets >150,000/mm³, normal ultrasound;
Group C, platelets <150,000/mm³, abnormal ultrasound (splenomegaly, nodular liver surface).

LS > 13.6 kPa in 54 patients
(8% A, 43% B, and 81% C)

All patients from groups B and C with LS>13.6 had PH.

250 consecutive patients

Group A, platelets >150,000/mm³, normal abdominal ultrasound;
Group B, platelets >150,000/mm³, normal ultrasound;
Group C, platelets <150,000/mm³, abnormal ultrasound (splenomegaly, nodular liver surface).

LS > 13.6 kPa in 54 patients
(8% A, 43% B, and 81% C)

All patients from groups B and C with LS>13.6 had PH.

Detection of Early Portal Hypertension with Routine Data and Liver Stiffness in Patients with Asymptomatic Liver Disease: A Prospective Study

250 consecutive patients

Group A, platelets >150,000/mm³, normal abdominal ultrasound;
Group B, platelets >150,000/mm³, normal ultrasound;
Group C, platelets <150,000/mm³, abnormal ultrasound (splenomegaly, nodular liver surface).

LS > 13.6 kPa in 54 patients
(8% A, 43% B, and 81% C)

All patients from groups B and C with LS>13.6 had PH.