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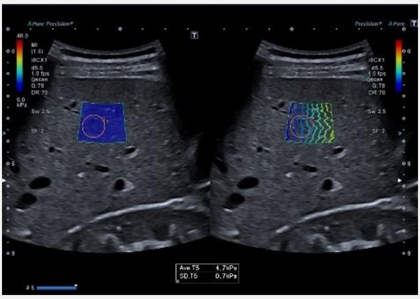
Liver Analysis

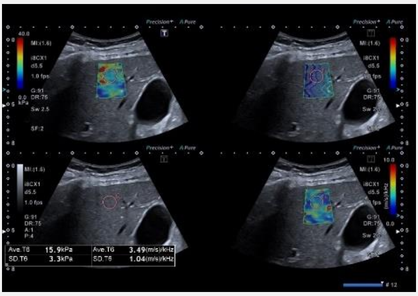
Aplio

SWE Elasticity



ATI Steatosis

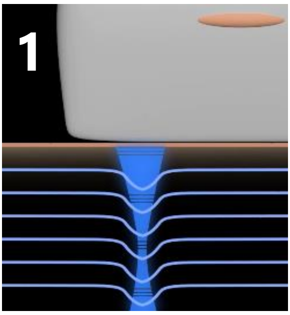
SWD Viscosity



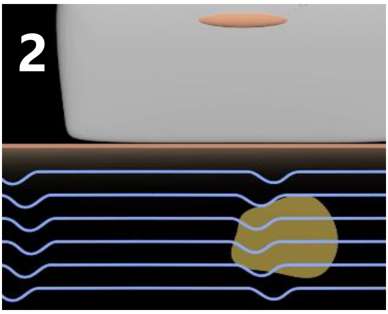
Click for more info

Shear Wave Physics

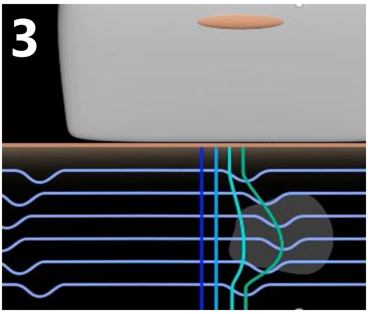
- High power focused ultrasound pulse generates a lateral tissue displacement. It is called shear wave.
- Shear wave speed is related to tissue stiffness. Waves tracking and analysis allows to calculate tissue stiffness by Young Modulus.



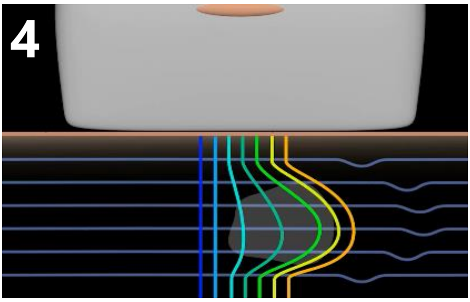
Focussed Pulse Generates Shear Wave



Propagation of Shear Wave in tissues



Shear wave velocity changed following tissue hardness



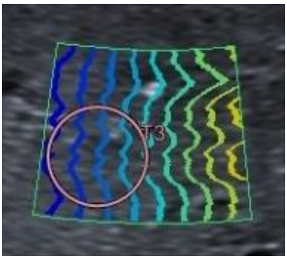
Lesion harder than the surrounding tissue : fast shear wave

Back

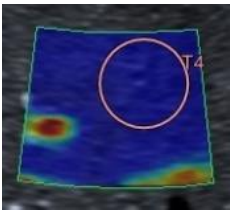
Shear Wave Propagation Mode

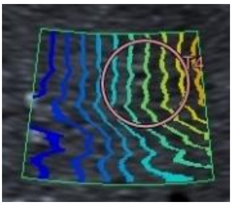
- The propagation mode is an exclusive mode for representing the profile of Shear Waves.
- This propagation profile is useful to evaluate propagation quality in uniform tissues (Liver)

Propagation tracking starts from dark blue to warm colors

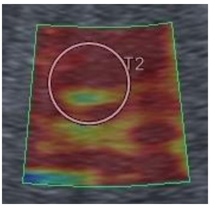


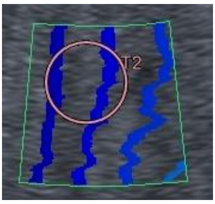
The Shear Waves are "slower" in the softer areas





The Shear Waves are " accelerated" in the stiffer areas





Propagation Map: Display – Select Prop

Remove – Select B

Back

Important Notes

- **Values :**
  Elasticity, attenuation or dispersion values must be used only by trained users, aware of the technology and its limits.
  Moreover, these results should never be used alone and always correlated with clinical or other imaging techniques.

- **Attenuation :**
  Insufficient tissue displacement by the push pulse may make it difficult to generate the shear wave amplitude required to measure the shear wave speed and elasticity. It may be caused by phase aberration, refraction or tissue attenuation: Excessive wall thickness or steatosis liver.

- **Reverberation :**
  Shear waves are also affected by reverberation artefacts that can display false stiff areas on superficial interfaces.

- **Liquids :**
  The shear waves do not propagate in non- viscous liquids. However diffraction artifacts from adjacent structures can be observed in cystic structures (especially small cysts) .

- **Lesions :**
  Shear waves propagation is uniform in homogeneous tissue. The propagation mode allows to evaluate the quality before making a measurement. However in the case of a rigid and / or heterogeneous lesions , the analysis of this propagation profile does not provide any information about the quality of this acquisition.
  In the case of extremely stiff lesions, if it exceeds 200 kPa , unencrypted areas can occur without affecting the quality of the acquisition.

- **Liver Capsule artifact :**
  Area under the liver capsule can be very stiff and not representative about the global liver stiffness.

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SWE, ATI & SWD Compatible Probes

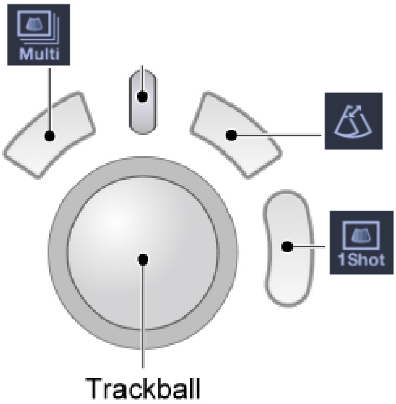
Abdominal Probes

PVI – 475BX

PVI/T – 475BT

Back

Shear Wave Acquisition Modes



Start on TCS

Real Time Shear Wave acquisition

(Recommended)

Single One Shot acquisition with maximum power and resolution

Note , After a One Shot mode acquisition, a cooling time is required, in which the probe is automatically frozen for 5 seconds.

Back

Shear Wave Acquisition Modes

- **Recommended Settings:**

Parameter	Range	Recommended Value
Preset		**Fibrosis**
Mode		**Multi**
Range		**0 – 45 kPa**
Smoothing	0 – 5	**2**
FR Control	0 – 3	**3**
Time Smoothing	0 – 5	**4**
Diff Pitch	0 – 4	**2**
Color Map	0 – 5	**0**
Opacity	0 – 1	**0,5**
Resolution	0 – 3	**2**
Focus	0 – 100%	**75%**
Track Freq	0	**2,2**

Back

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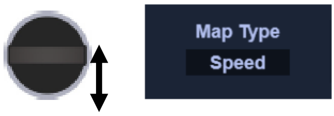
Shear Wave Mapping

- **Map Types:**
  - **Speed:** Shear wave velocity map (m/s)
  - **Elasticity:** Elasticity map (kPa)
  - **Propagation:** Mapping of the shear wave propagation profile – Unique
  - **Select:** Dispersion or Variance mapping

Switch from elasticity to speed mapping via the dial Map Type . This setting is possible in real time and frozen image.

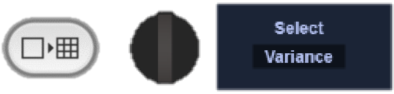


Scale is adjusted by the dial Range Max (speed : max 10 m/s / Elast : max 200 kPa) This setting is available in real time and post freeze.

Recommended scale: Liver: 0 – 45 kPa

- **Dispersion Mapping:**
  - Change display to quad mode
  - Dispersion mapping is displayed in bottom right image

Display Dispersion or Variance Mapping



Back

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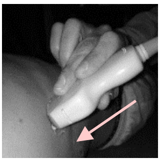
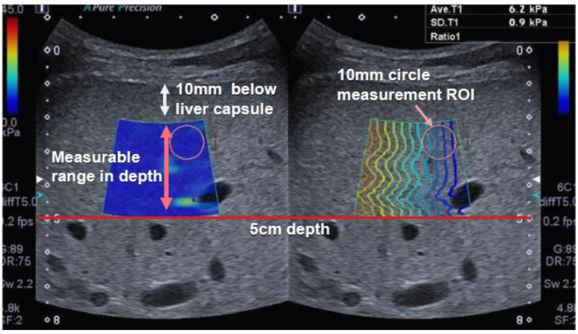
Shear Wave Acquisition Protocol

1	Patient fasted for > 4 hours
2	Patient in supine position
3	Right liver Intercostal approach (mostly segment VII/VIII)
4	Probe perpendicular to the skin

5	Liver capsule, echogenic and displayed horizontally
6	High quality B-mode image free of vessels or shadowing/reverberation artifacts
7	SWE box placed 1 cm below the liver capsule

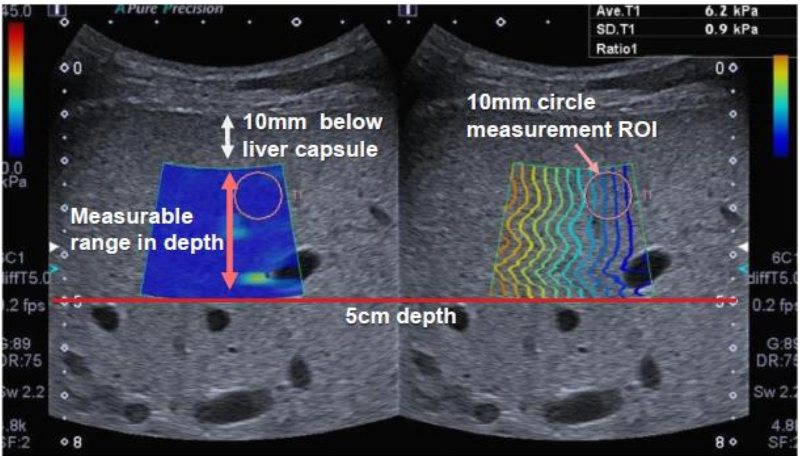


8	Complete the SWE acquisition on a neutral stop breathing (no deep apneia)

Back

Shear Wave Measurement Protocol

1	ROI Shape/Size: circle/10mm diameter
2	The center of the ROI should not be placed at a depth greater than 5cm
3	Place the ROI on the most parallel propagation map area
4	Use predominantly, the upper and dark blue area or the propagation map
5	Place only one ROI per acquisition*
6	**Use median value after 3 acquisitions**



Back

Liver Fibrosis Assessment

Indicative values for Hepatic Fibrosis*

- **Comparison of Liver Stiffness Measurement by 2D-Shearwave and Transient Elastography: Results from a European prospective Multi-Centre study**

Maxime Ronot, Giovanna Ferraioli, Hans-Peter Mueller, Mireen Friedrich-Rust, Carlo Filice, Valérie Vilgrain, late David Cosgrove, Adrian K Lim (2020)

- **European multi centric study**
- **537 patients included**
- **European Radiology** https://doi.org/10.1007/s00330-020-07212-x

- 2D SWE can differentiate patients with Normal/Mild Fibrosis and Cirrhosis
- 2D SWE allows a lower number of acquisitions than TE for similar results thereby reducing examination times: 3 measurements is sufficient.

Stage	Fibrosis Stage	Speed (m/s)	**Elasticity (kPa)**
F0-F1	No Fibrosis	< 1,52	**< 7.0**
≥ F2	Significant	1,52 - 1,63	**7,1 – 8,0**
≥ F3	Advanced	1,64 – 1,87	**8,1 – 10.5**
F4	Cirrhosis	> 1,87	**> 10.5**

The values mentioned in this document are according to specific scientific literature, only indicative and non exhaustive.

Healthcare professionals are the only guarantor of the diagnosis which should always be done considering the patient's clinical background. Each Department is responsible for selection and validation of their protocol.

Canon Medical is not responsible for the misuse or misinterpretation based on these values.

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SWE Liver

Performance and cutoffs for liver fibrosis staging of a two-dimensional shear wave elastography technique

The results of this study show that this 2D-shear wave elastography technique is accurate for staging liver fibrosis.

Cutoff values:

- **7 kPa significant fibrosis F2**
- **9 kPa Severe Fibrosis F3-F4**

Original article

Performance and cutoffs for liver fibrosis staging of a two-dimensional shear wave elastography technique

Giovanna Ferraioli,[a,b] Laura Maiocchi,[b] Carolina Dellafiore,[a,b] Carmine Tinelli,[c] Elisabetta Above[b] and Carlo Filice[a,b]

Objectives: To assess performance and cutoffs of the 2-dimensional shear wave elastography technique available on the Aplio i800 ultrasound system (Canon Medical Systems, Japan), using transient elastography as reference standard, and to assess the correlation of shear-wave-speed dispersion with liver fibrosis or steatosis.
Methods: This was a single-center cross-sectional study. The correlations between values obtained with transient elastography and 2-dimensional-shear wave elastography, and between shear-wave-speed dispersion and fibrosis or steatosis, were assessed with Pearson's *r*. The diagnostic performance of the 2-dimensional-shear wave elastography for staging significant fibrosis and severe fibrosis compared to transient elastography was assessed using the area under the receiver operating characteristic curve analysis.
Results: Three hundred sixty-seven patients (198 males and 169 females) were studied. There was a high correlation between 2-dimensional-shear wave elastography and transient elastography ($r = 0.87$, $P < 0.0001$). The area under the receiver operating characteristics of 2-dimensional-shear wave elastography for staging significant fibrosis (F2) and severe fibrosis (F3–F4), respectively, were 0.97 (95% confidence interval, 0.91–0.98) and 0.97 (95% confidence interval, 0.95–0.99). The best cutoffs for significant fibrosis and severe fibrosis, respectively, were > 7 and > 9 kPa. Shear-wave-speed dispersion showed a high correlation with fibrosis ($r = 0.85$, $P < 0.0001$), whereas there was a very weak correlation with steatosis.
Conclusions: The results of this study show that this 2-dimensional-shear wave elastography technique is accurate for staging liver fibrosis. Shear-wave-speed dispersion is highly correlated with liver fibrosis but not with steatosis. Eur J Gastroenterol Hepatol XXX: 00–00

Introduction

Liver fibrosis, which is due to the healing process of necroinflammation, is a common feature of chronic liver disease; it may lead to cirrhosis with its complications. For the treatment and prognosis of patients with chronic liver disease, it is important to assess whether the patient has significant fibrosis (F2 stage) or liver cirrhosis (F4 stage) [1]. On the other hand, the spectrum of fibrosis is a continuum; therefore, the term 'compensated advanced chronic liver disease,' which includes severe fibrosis (F3) and liver cirrhosis (F4) at an early [2]. In fact, esophageal varices can occur not only in patients with established cirrhosis but also in patients with severe fibrosis [2,3].

Nowadays, guidelines have accepted that liver stiffness assessment with shear wave elastography (SWE) can replace liver biopsy in several clinical scenarios [4].

Indeed, several studies and meta-analyses have shown that the SWE techniques are accurate for the evaluation of liver fibrosis. The first SWE technique available on the market was transient elastography (TE), which is performed with a dedicated device. It has become a point-

Journal Info	European Journal of Gastroenterology & Hepatology Feb 2020 https://doi.org/10.1097/MEG.0000000000001702
Year	**2020**
Authors	G. Ferraioli, L. Maiocchi, C. Dellafiore, C. Tinelli, C. Filice (Italy)
System used	Aplio i800

Back

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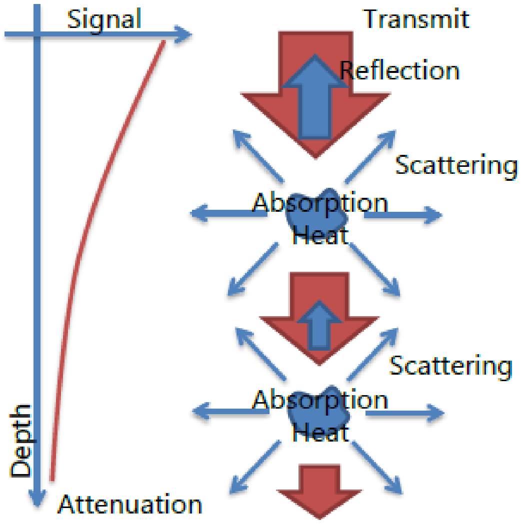
Attenuation Imaging Physics

- As ultrasound travels through the tissues, it is attenuated by acoustic scattering, reflection, and absorption (heat).
- Attenuation imaging measures the difference in ultrasound transmission along the travelled depth.

- Attenuation is frequency-dependent.



Tissue	Attenuation Coefficient (dB/cm/MHz)
Blood	0.12 – 0.16
Liver	0.45 – 0.52
Fat	0.6 – 1.0
Muscle	0.57 - 2

Duck FA. (1990). Physical Properties of Tissue: A comprehensive review

Back

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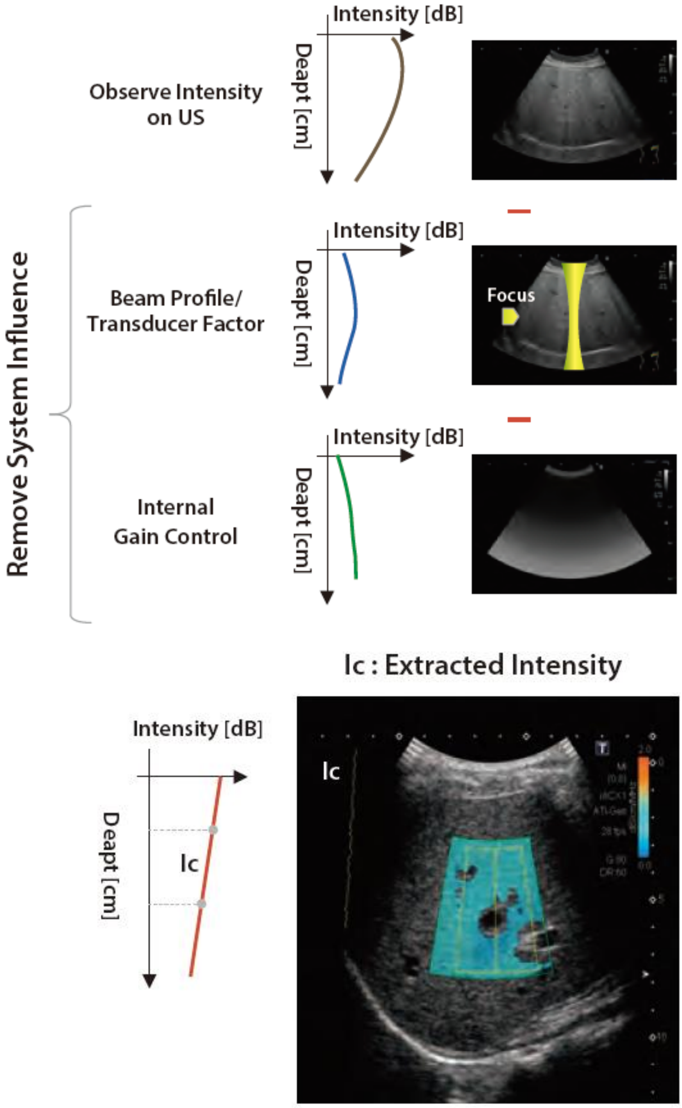
Attenuation Imaging Physics

- ATI algorithm excludes external intensity factors like: focus, beam and internal gain control

- ATI is calculated based on the trend of the decline of intensity

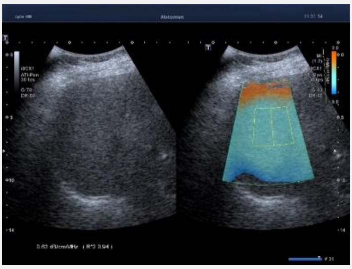


Back

Attenuation Imaging Acquisition

- **Conditions for an accurate measurement:**
- Attenuation coefficient is calculated using B-mode signal intensity, therefore B-mode image quality is important
- Use right intercostal window (similar to Shear wave)
- Try to get uniform mapping
- Avoid large vessels

- **Do not measure:**
- On the orange area on upper part of ROI (due to the liver capsule artifact)
- On the dark blue area at the bottom of ROI (weak signal and high noise level)
- Too close of shadowing artifacts areas
- Place ROI just below the orange area at liver capsule



- **Recommended settings:**

Parameter	Range	Recommended Value
ATI freq	ATI-Pen	**ATI-Pen**
Color Map	0-3	**3**
Opacity	0-1	**0.7**
Diff Pitch	0-4	**3**
Filter	0-3	**2**
B-Map	0-8	**2**

Back

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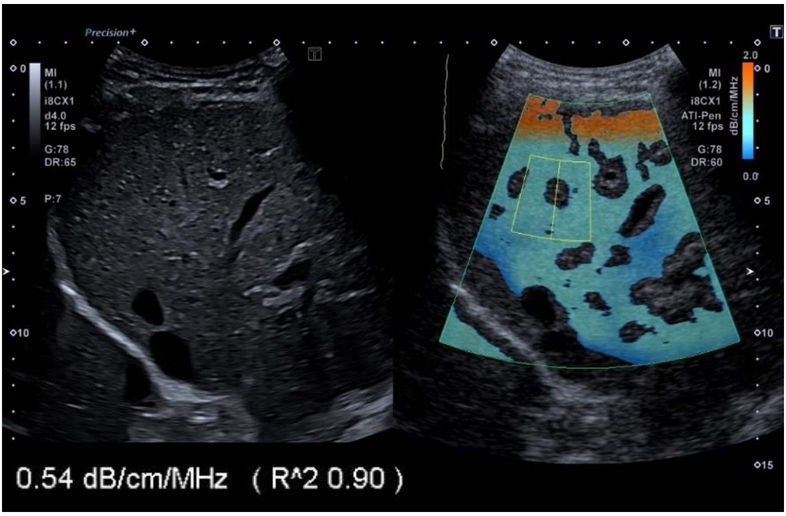
ATI
Acquisition Protocol

1. Patient supine position

2. Use same intercostal window as SW: Right liver Intercostal approach (segment VII/VIII predominantly)
   Probe perpendicular to the liver surface

3. Freeze when image includes parenchyma free or artifacts, shadows or large vessels

4. Measurement ROI is automatically outlined in yellow.



Measurement Protocol

1. Place ATI ROI just below the orange liver capsule artifact

2. Confirm **R^2 ≥ 0.85** (Displayed in yellow/white below the grayscale image).

3. If R^2 < 0,85 (displayed in yellow), restart acquisition

4. Use median value after 5 acquisitions

Back

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ATI Liver

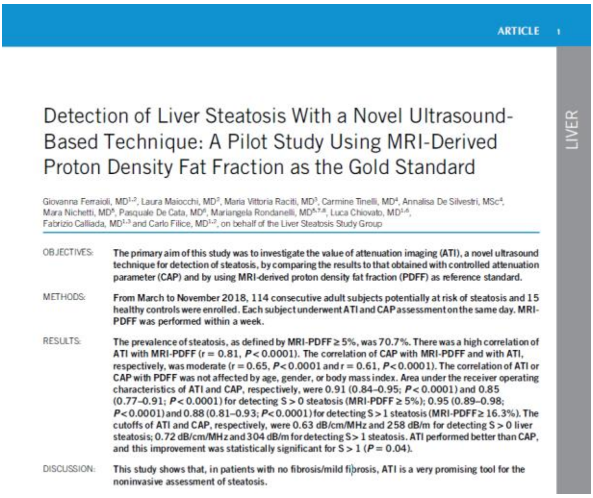
Detection of Liver Steatosis With a Novel Ultrasound-Based Technique: A Pilot Study Using MRI-Derived Proton Density Fat Fraction as the Gold Standard (2019)

Comparison of steatosis respective diagnostic performance between ATI and CAP vs MRI PDFF ("gold standard")

ATI performed better than CAP, and this improvement was statistically significant for S > 1

ATI Cutoff values for steatosis grading (dB/cm/kHz):

S0	No steatosis	**< 0,63**
S1	Mild Steatosis	**0,63 – 0,72**
S2-S3	Significant & Severe Steatosis	**> 0,72**



ARTICLE 1

LIVER

Detection of Liver Steatosis With a Novel Ultrasound-Based Technique: A Pilot Study Using MRI-Derived Proton Density Fat Fraction as the Gold Standard

Giovanna Ferraioli, MD[1,2], Laura Maiocchi, MD[2], Maria Vittoria Raciti, MD[3], Carmine Tinelli, MD[4], Annalisa De Silvestri, MSc[4], Mara Nichetti, MD[5], Pasquale De Cata, MD[6], Mariangela Rondanelli, MD[5,7,8], Luca Chiovato, MD[1,6], Fabrizio Calliada, MD[1,3] and Carlo Filice, MD[1,2], on behalf of the Liver Steatosis Study Group

OBJECTIVES: The primary aim of this study was to investigate the value of attenuation imaging (ATI), a novel ultrasound technique for detection of steatosis, by comparing the results to that obtained with controlled attenuation parameter (CAP) and by using MRI-derived proton density fat fraction (PDFF) as reference standard.

METHODS: From March to November 2018, 114 consecutive adult subjects potentially at risk of steatosis and 15 healthy controls were enrolled. Each subject underwent ATI and CAP assessment on the same day. MRI-PDFF was performed within a week.

RESULTS: The prevalence of steatosis, as defined by MRI-PDFF ≥ 5%, was 70.7%. There was a high correlation of ATI with MRI-PDFF (r = 0.81, $P < 0.0001$). The correlation of CAP with MRI-PDFF and with ATI, respectively, was moderate (r = 0.65, $P < 0.0001$ and r = 0.61, $P < 0.0001$). The correlation of ATI or CAP with PDFF was not affected by age, gender, or body mass index. Area under the receiver operating characteristics of ATI and CAP, respectively, were 0.91 (0.84–0.95; $P < 0.0001$) and 0.85 (0.77–0.91; $P < 0.0001$) for detecting S > 0 steatosis (MRI-PDFF ≥ 5%); 0.95 (0.89–0.98; $P < 0.0001$) and 0.88 (0.81–0.93; $P < 0.0001$) for detecting S > 1 steatosis (MRI-PDFF ≥ 16.3%). The cutoffs of ATI and CAP, respectively, were 0.63 dB/cm/MHz and 258 dB/m for detecting S > 0 liver steatosis; 0.72 dB/cm/MHz and 304 dB/m for detecting S > 1 steatosis. ATI performed better than CAP, and this improvement was statistically significant for S > 1 ($P = 0.04$).

DISCUSSION: This study shows that, in patients with no fibrosis/mild fibrosis, ATI is a very promising tool for the noninvasive assessment of steatosis.

Journal Info	Clinical and Translational Gastroenterology 2019;00:e00081 https://doi.org/10.14309/ctg.0000000000000081
Year	**2019**
Authors	G. Ferraioli, L. Maiocchi, R. Lissandrin, C. Tinelli, F. Calliada, C. Filice (Italy)
System used	Aplio i800

Back

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ATI Liver

Assessment of hepatic steatosis by using attenuation imaging: A quantitative, easy-to-perform ultrasound technique

The acoustic coefficient (AC) from ATI provided good diagnostic performance in detecting the varied degrees of hepatic steatosis. The degree of steatosis was the only significant factor affecting the AC, whereas fibrosis and inflammation did not.

Cutoff values for steatosis grading (dB/cm/kHz):

S0	S1	S2	S3
No Steatosis	Mild Steatosis	Moderate Steatosis	Severe Steatosis
< 0,63	**< 0,70**	**> 0,70**	**> 0,75**

European Radiology
https://doi.org/10.1007/s00330-019-06272-y

HEPATOBILIARY-PANCREAS

Check for updates

Assessment of hepatic steatosis by using attenuation imaging: a quantitative, easy-to-perform ultrasound technique

Jae Seok Bae[1,2] · Dong Ho Lee[1,2] · Jae Young Lee[1,2,3] · Haeryoung Kim[4] · Su Jong Yu[5] · Jeong-Hoon Lee[5] · Eun Ju Cho[5] · Yun Bin Lee[5] · Joon Koo Han[1,2,3] · Byung Ihn Choi[6]

Received: 27 February 2019 /Revised: 2 May 2019 / Accepted: 10 May 2019

Abstract

Objectives To evaluate the diagnostic performance of attenuation imaging (ATI) in the detection of hepatic steatosis compared with a histopathology gold standard.

Methods We prospectively enrolled 108 consecutive patients (35 males; median age, 54.0 years) who underwent percutaneous liver biopsy for evaluation of diffuse liver disease between January 2018 and November 2018 in a tertiary academic center. Grayscale ultrasound examination with ATI was performed just before biopsy, and an attenuation coefficient (AC) was obtained from each patient. The degree of hepatic steatosis, fibrosis stage, and necroinflammatory activity were assessed on histopathologic examination. The significant factor associated with the AC was found by a linear regression analysis, and the diagnostic performance of the AC for the classification into each hepatic steatosis stage was evaluated by receiver operating characteristic (ROC) analysis.

Results The distribution of hepatic steatosis grade on histopathology was 53/11/22/16/6 for none/mild (< 10%)/mild (≥ 10%)/

Journal Info	European radiology https://doi.org/10.1007/s00330-019-06272-y
Year	**2019**
Authors	Jae Seok Bae, Dong Ho Lee, Jae Young Lee, Haeryoung Kim, Su Jong Yu, Jeong-Hoon Lee, Eun Ju Cho & al
System used	Aplio i800

Back

CANON MEDICAL

ATI Liver

Prospective Evaluation of Hepatic Steatosis using Ultrasound Attenuation Imaging in Patients with Chronic Liver Disease with Magnetic Resonance Imaging Proton Density Fat Fraction as the Reference Standard

ATI attenuation coefficients are well correlated with MRI-PDFF and, thus, may provide good diagnostic performance in the assessment of hepatic steatosis, making these coefficients a promising tool for the non-invasive assessment and quantification of hepatic steatosis

Cutoff value for detection of steatosis

- **MRI-PDFF > 5%** **0,59 dB/cm/MHz**
- **MRI-PDFF > 10%** **0,65 dB/cm/MHz**

ELSEVIER

Check for updates

Ultrasound in Med. & Biol., Vol. 45, No. 6, pp. 1407–1416, 2019

0301-5629/$ - see front matter

https://doi.org/10.1016/j.ultrasmedbio.2019.02.008

● *Original Contribution*

PROSPECTIVE EVALUATION OF HEPATIC STEATOSIS USING ULTRASOUND ATTENUATION IMAGING IN PATIENTS WITH CHRONIC LIVER DISEASE WITH MAGNETIC RESONANCE IMAGING PROTON DENSITY FAT FRACTION AS THE REFERENCE STANDARD

SUN KYUNG JEON,[*] JEONG MIN LEE,[*,†,‡] IJIN JOO,[*,†] JEONG HEE YOON,[*,†] DONG HO LEE,[*,†]
JAE YOUNG LEE,[*,†,‡] and JOON KOO HAN[*,†,‡]

[*] Department of Radiology, Seoul National University Hospital, Seoul, South Korea; [†] Seoul National University College of Medicine, Seoul, South Korea; and [‡] Institute of Radiation Medicine, Seoul National University Medical Research Center, Seoul, South Korea

(*Received* 26 *October* 2018; *revised* 31 *January* 2019; *in final from* 6 *February* 2019)

Abstract—The purpose of our study was to investigate the diagnostic performance of 2-D ultrasound attenuation imaging (ATI) for the assessment of hepatic steatosis in patients with chronic liver disease using magnetic resonance imaging proton density fat fraction (MRI-PDFF) as the reference standard. We prospectively analyzed 87 patients with chronic liver disease who had reliable measurements at both ATI and MRI-PDFF. For the detection of hepatic steatosis of MRI-PDFF ≥5% and MRI-PDFF ≥10%, ATI measurements yielded areas under the

Journal Info	Ultrasound in Med. & Biol., Vol. 45, No. 6, pp. 14071416 https://doi.org/10.1016/j.ultrasmedbio.2019.02.008
Year	**2019**
Authors	Adegpst Un Kyung Jeon, Jeong Min Lee, Ijin Joo, Jeong Hee Yoon, Dong Ho Lee, Jae Young Lee, Joon Koo Han (Korea)
System used	Aplio i800

Back

ATI Liver

Quantification of hepatic steatosis with ultrasound: promising role of attenuation imaging coefficient in a biopsy-proven cohort

ATI coefficient has a significant positive correlation with the grade of steatosis and is a promising quantitative technique for the noninvasive diagnosis and quantification of hepatic steatosis.

Measurement of the attenuation coefficient is achieved with a very high rate of technical success.

Cutoff value for detection of steatosis

- **S0 vs S1-2-3** **0,69 dB/cm/MHz**
- **S0-1 vs S2-3** **0,72 dB/cm/MHz**

European Radiology
https://doi.org/10.1007/s00330-019-06480-6

GASTROINTESTINAL

Check for updates

Quantification of hepatic steatosis with ultrasound: promising role of attenuation imaging coefficient in a biopsy-proven cohort

Marco Dioguardi Burgio[1,2] · Maxime Ronot[1,2,3] · Edouard Reizine[1] · Pierre-Emmanuel Rautou[4] · Laurent Castera[4] · Valérie Paradis[5] · Philippe Garteiser[2] · Bernard Van Beers[1,2,3] · Valérie Vilgrain[1,2,3]

Received: 12 March 2019 / Revised: 30 August 2019 / Accepted: 27 September 2019

Abstract

Objectives To prospectively assess the role of the US attenuation imaging coefficient (AC) for the diagnosis and quantification of hepatic steatosis.

Methods One hundred and one patients underwent liver biopsy and US-AC measurement on the same day. Liver steatosis was graded according to biopsy as absent (S0 < 5%), mild (S1 5–33%), moderate (S2 33–66%), or severe (S3 > 66%); liver fibrosis was graded from F0 to F4. The correlation between AC and steatosis on pathology (%) was calculated using the Pearson correlation coefficient. The Student *t* or Mann–Whitney *U* test was used to compare continuous variables and ROC curve analysis was used to assess diagnostic performance of AC in diagnosing steatosis.

Results Overall, 43 (42%), 35 (35%), 12 (12%), and 11 (11%) patients were classified as S0, S1, S2, and S3, respectively. The AC was positively correlated with steatosis as a continuous variable (%) on pathology ($r = 0.58$, $p < 0.01$). Patients with steatosis of any grade had a higher AC than those without steatosis (mean 0.77 ± 0.13 vs. 0.63 ± 0.09 dB/cm/MHz, respectively; $p < 0.01$, AUROC = 0.805). Patients with S2–S3 had a higher AC than patients with S0–1 (0.85 ± 0.11 vs. 0.67 ± 0.11 dB/cm/MHz, respectively; $p < 0.01$, AUROC = 0.892). AC > 0.69 dB/cm/MHz had a sensitivity and specificity of 76% and 86%, respectively, for diagnosing any grade of steatosis (S1–S3), and AC > 0.72 dB/cm/MHz had a sensitivity and specificity of 96% and 74%, respectively, for diagnosing S2–S3. The presence of advanced fibrosis (F3–F4) did not affect the calculated AC.

Conclusions The attenuation imaging coefficient is a promising quantitative technique for the non-invasive diagnosis and quantification of hepatic steatosis.

Key Points

- *Measurement of the attenuation coefficient is achieved with a very high rate of technical success.*
- *We found a significant positive correlation between the attenuation coefficient and the grade of steatosis on pathology.*
- *The attenuation imaging coefficient is a promising quantitative technique for the noninvasive diagnosis and quantification of hepatic steatosis.*

Keywords Liver steatosis · Ultrasonography · NAFLD

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Year	**2019**
Authors	Marco Dioguardi Burgio, Maxime Ronot, Edouard Reizine, Pierre-Emmanuel Rautou, Laurent Castera, Valérie Paradis, Philippe Garteiser, Bernard Van Beers, Valérie Vilgrain (France)
System used	Aplio i800

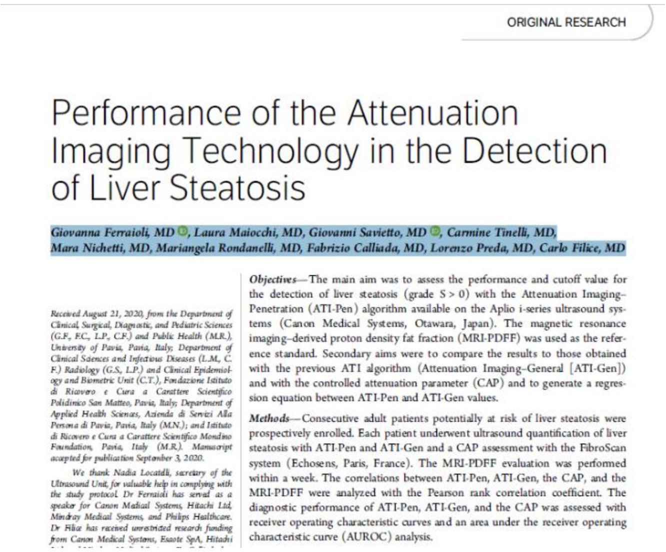
Back

CANON MEDICAL

ATI Liver

Performance of the Attenuation Imaging Technology in the Detection of Liver Steatosis

Attenuation Imaging is a reliable tool for detecting liver steatosis, showing an excellent correlation with the MRI-PDFF and high performance with AUROCs of 0.90 or higher.


ORIGINAL RESEARCH

Performance of the Attenuation Imaging Technology in the Detection of Liver Steatosis

Giovanna Ferraioli, MD, Laura Maiocchi, MD, Giovanni Savietto, MD, Carmine Tinelli, MD, Mara Nichetti, MD, Mariangela Rondanelli, MD, Fabrizio Calliada, MD, Lorenzo Preda, MD, Carlo Filice, MD

Objectives—The main aim was to assess the performance and cutoff value for the detection of liver steatosis (grade S > 0) with the Attenuation Imaging–Penetration (ATI-Pen) algorithm available on the Aplio i-series ultrasound systems (Canon Medical Systems, Otawara, Japan). The magnetic resonance imaging–derived proton density fat fraction (MRI-PDFF) was used as the reference standard. Secondary aims were to compare the results to those obtained with the previous ATI algorithm (Attenuation Imaging–General [ATI-Gen]) and with the controlled attenuation parameter (CAP) and to generate a regression equation between ATI-Pen and ATI-Gen values.

Methods—Consecutive adult patients potentially at risk of liver steatosis were prospectively enrolled. Each patient underwent ultrasound quantification of liver steatosis with ATI-Pen and ATI-Gen and a CAP assessment with the FibroScan system (Echosens, Paris, France). The MRI-PDFF evaluation was performed within a week. The correlations between ATI-Pen, ATI-Gen, the CAP, and the MRI-PDFF were analyzed with the Pearson rank correlation coefficient. The diagnostic performance of ATI-Pen, ATI-Gen, and the CAP was assessed with receiver operating characteristic curves and an area under the receiver operating characteristic curve (AUROC) analysis.

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We thank Nadia Locatelli, secretary of the Ultrasound Unit, for valuable help in complying with the study protocol. Dr Ferraioli has served as a speaker for Canon Medical Systems, Hitachi Ltd, Mindray Medical Systems, and Philips Healthcare. Dr Filice has received unrestricted research funding from Canon Medical Systems, Esaote SpA, Hitachi

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Year	**2020**
Authors	Giovanna Ferraioli, MD , Laura Maiocchi, MD, Giovanni Savietto, MD , Carmine Tinelli, MD, Mara Nichetti, MD, Mariangela Rondanelli, MD, Fabrizio Calliada, MD, Lorenzo Preda, MD, Carlo Filice, MD
System used	Aplio i800

Back

Multiparametric Report

- **Exam report:**
- Press the report button on the left hand side row of the touch command screen, to display all measurements:
  - Mean
  - Standard deviation
  - Median
  - Interquartile range IQR
  - IQR/Median

Application Measurement 2022/10/20		Speed [m/s]	Elasticity [kPa]	Dispersion [(m/s)/kHz]	ATI [dB/cm/MHz]
	Mean	2.52	20.7	22.7	0.74
	SD	0.35	5.4	3.9	0.06
	Median	2.73	24.3	24.4	0.71
	IQR	0.79	11.8	9.1	0.14
	IQR/Median	0.29	0.49	0.37	0.20

Median

Median represents the liver stiffness (most robust parameter)

SWE IQR/Median

IQR/Median evaluate examination quality (measurements variability)

IQR/Median < 0,3

The values mentioned in this document are according to specific scientific literature, only indicative and non exhaustive.

Healthcare professionals are the only guarantor of the diagnosis which should always be done considering the patient's clinical background. Each Department is responsible for selection and validation of their protocol.

Canon Medical is not responsible for the misuse or misinterpretation based on these values.

Back

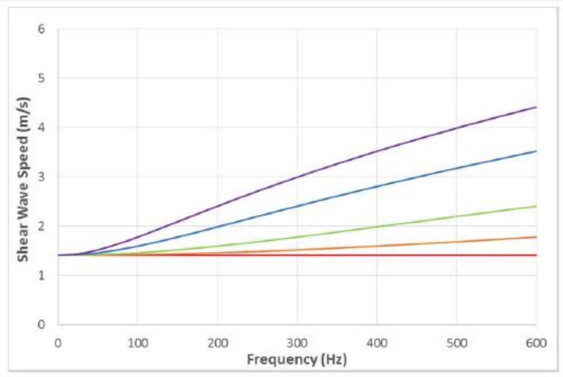
Dispersion Physics

- Every tissue like liver tissue has both elasticity and viscosity component
  - Current shear wave measures only elasticity
  - Some liver diseases can also affect liver viscosity

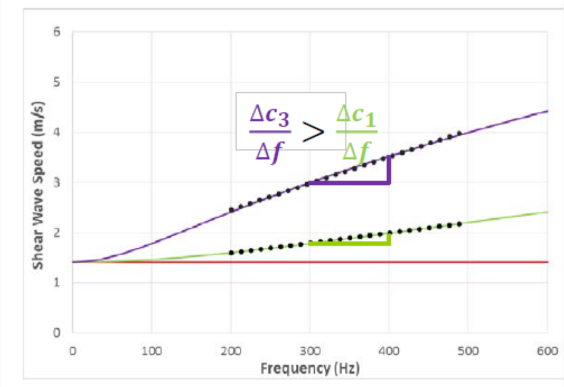
- Shear wave speed varies with frequency and measure the level of frequency dependency of shear speed which is called Dispersion of frequency.
- The Dispersion is correlated with viscosity.
- The Dispersion 2D mapping can be obtained quantitatively together with shear wave speed/Elasticity mapping and propagation mapping

Higher shear wave speed Dispersion

Higher Viscosity



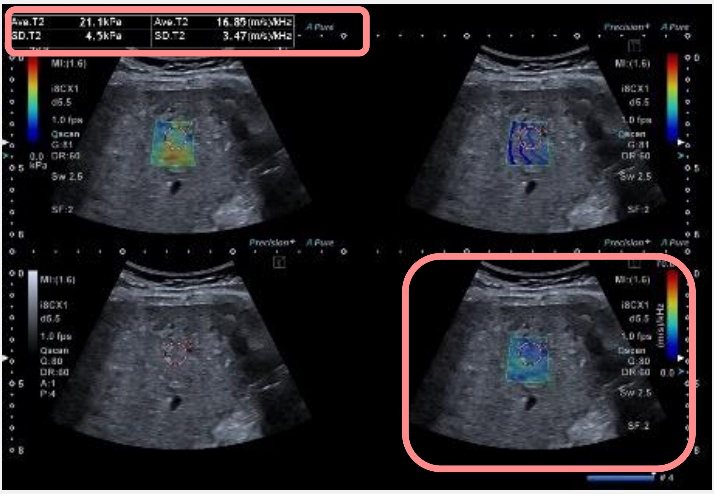
Dispersion can be quantified by determining the change of speed over a given frequency range (i. e. slope)



Dispersion Acquisition

- **Dispersion measurement as an indicator of viscosity**
- Dispersion is automatically calculated when performing shear wave measurement
- Dispersion value is available in the report
- Dispersion value is not displayed in Dual mode

- Dispersion value is displayed only in quad mode



Change display to quad mode:

- Dispersion mapping is displayed in bottom right image
- Dispersion measurement is displayed

Ave.T2	21.1kPa	Ave.T2	16.85(m/s)/kHz
SD.T2	4.5kPa	SD.T2	3.47(m/s)/kHz

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SWD Liver

Clinical utilization of shear wave dispersion imaging in diffuse liver disease

SW dispersion slope is more useful than SW speed for predicting the degree of necro-inflammation.

Dispersion slope, which reflects viscosity, may provide additional pathophysiological insight into diffuse liver disease.

Clinical utilization of shear wave dispersion imaging in diffuse liver disease

ULTRA SONO GRAPHY

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REVIEW ARTICLE

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Shear wave (SW) dispersion imaging is a newly developed imaging technology for assessing the dispersion slope of SWs, which is related to tissue viscosity in diffuse liver disease. Our preclinical and preliminary clinical studies have shown that SW speed is more useful than dispersion slope for predicting the degree of fibrosis and that dispersion slope is more useful than SW speed for predicting the degree of necroinflammation. Thus, dispersion slope, which reflects viscosity, may provide additional pathophysiological insight into diffuse liver disease.

Keywords: Ultrasonography; Elasticity; Viscosity; Dispersion; Shear wave elastography; Liver

Introduction

Shear wave elastography (SWE) is an emerging technology that provides information concerning tissue elasticity by emitting an acoustic radiation force impulse to generate laterally propagating shear waves (SWs), and it can also provide biochemical information concerning tissue quality [1–3]. Furthermore, viscosity also provides biochemical information concerning tissue quality, as viscosity is considered to be a different property than elasticity [4–6]. However, most ultrasound (US) elastographic models use a linear elastic model to describe tissue mechanical properties, and only tissue elasticity is quantified. It is now well known that dispersion is related to the frequency-dependence of the speed of SWs and the attenuation of SWs in the viscous component [7]. If a tissue is dispersive, the speed and attenuation of SWs increase with frequency [7]. Analysis of the dispersion properties of SWs can therefore serve as an indirect method for measuring viscosity. A new imaging technology known as shear wave dispersion imaging (SWD; Canon Medical Systems Corporation, Otawara, Japan) has recently been developed for evaluating the dispersion of SWs, which is related to the viscosity of liver tissue [8]. In this review article, the feasibility of liver viscosity evaluation using SWD is assessed based on the findings of preliminary animal experiments and clinical evaluations.

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Year	**2019**
Authors	Katsutoshi Sugimoto, Fuminori Moriyasu, Hisashi Oshiro, Hirohito Takeuchi, Yu Yoshimasu, Yoshitaka Kasai, Takao Itoi (Japan)
System used	Aplio i800

i800 Research Tool

Back

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SWD Liver

Shear-Wave Dispersion Slope from US SWE: Detection of Allograft Damage after Liver Transplantation

Shear-wave dispersion slope is associated with both liver fibrosis and degree of necro-inflammatory activity (*P* , .01) after liver transplant and provided **better diagnostic performance than liver stiffness value in detection of allograft damage after liver transplant**.

Cutoff SWD (m/s/kHz)	Sensitivity	Specificity	PPV	NPV
10,8	97,8	62,1	67%	**97%**
12	80,4	67,2	66%	81%
14	56,5	86,2	**76%**	71%

Radiology

ORIGINAL RESEARCH • GASTROINTESTINAL IMAGING

Shear-Wave Dispersion Slope from US Shear-Wave Elastography: Detection of Allograft Damage after Liver Transplantation

Dong Ho Lee, MD • Jae Young Lee, MD • Jae Seok Bae, MD • Nam-Joon Yi, MD • Kwang-Woong Lee, MD • Kyung-Suk Suh, MD • Haeryoung Kim, MD • Kyung Bun Lee, MD • Joon Koo Han, MD

From the Departments of Radiology (D.H.L., J.Y.L., J.S.B., J.K.H.), Surgery (N.J.Y., K.W.L., K.S.S.), and Pathology (H.K., K.B.L.), Seoul National University Hospital, 101 Daehangno, Jongno-gu, Seoul 03080, Korea; and Institute of Radiation Medicine, Seoul National University College of Medicine, Seoul, Korea (J.Y.L., J.K.H.).
Received January 9, 2019; revision requested February 25; revision received July 5; accepted July 31. **Address correspondence to** J.Y.L. (e-mail: *Leejy4u@snu.ac.kr*).

Conflicts of interest are listed at the end of this article.

Radiology 2019; 00:1–8 • https://doi.org/10.1148/radiol.2019190064 • Content code: GI

Background: Allograft damage (hepatic parenchymal damage) after liver transplant is associated with the degree of necroinflammation in graft liver. According to a recent animal study, shear-wave dispersion slope obtained at US shear-wave elastography (SWE) is associated with necroinflammatory activity in the liver.

Purpose: To evaluate the role of shear-wave dispersion slope in detecting allograft damage after liver transplant.

Materials and Methods: In this prospective study, 104 liver transplant recipients underwent percutaneous liver biopsy for allograft evaluation from December 2017 to November 2018. All participants underwent allograft SWE examination just before liver biopsy, and liver stiffness and shear-wave dispersion slope were obtained. Allograft damage was diagnosed by histopathologic analysis. Clinical and imaging factors related to liver stiffness and shear-wave dispersion slope were determined by multivariable linear regression analysis. Diagnostic performance of each variable in detecting allograft damage was evaluated by comparing area under the receiver operating curve (AUC) values.

Journal Info	Radiology 2019; 00:1–8 https://doi.org/10.1148/radiol.2019190064
Year	**2019**
Authors	Jeong Hee Yoon, Dong Ho Lee, Jae Young Lee, Joon Koo Han (Korea)
System used	Aplio i800

i800 Research Tool

Back

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