8th SJRS Symposium &
11th NJPACS Symposium

Real-time Tissue Elastography

Ellison Bibby

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Hitachi Medical Systems Europe
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Diagnostic Imaging. Vol. No. December 4, 2009

Diagnostic Imaging.

Is elastography the next color Doppler?

By Greg Freiherr | 04 December 2009

HI-RTE
Hitachi Real-time Tissue Elastography

Real-time Tissue Elastography

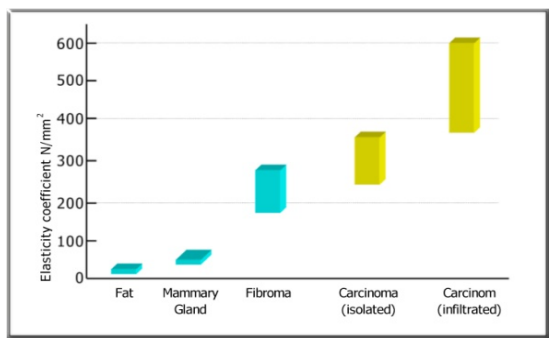
Contents

Author: E Bibby

- Estimation of tissue stiffness by palpation is one of key methods traditionally used by physicians to diagnose disease
- Palpation is subjective and lacks sensitivity especially for small lesions and at deep locations
- Ophir et al[1] first described a method for imaging the elasticity of tissues in 1991
- Krouskop et al[2] showed that there is a large contrast between the stiffness of normal breast tissue and that of cancerous lesions and between normal prostate tissue and prostate cancer

[1]Elastography: a quantitative method for imaging the elasticity of biological tissues. *Ophir et al, Ultrason Imaging 1991;13(2):111-134*

[2]Elastic moduli of breast and prostate tissues under compression. *Krouskop et al, Ultrason Imaging 1998:20(4):260-74*



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Elasticity Modulus, E

- The elasticity modulus is a measure of the stiffness of a given material
- Defined as the rate of change of stress with strain

$$E = \frac{\sigma}{\varepsilon}$$

σ = tensile stress, ε = tensile strain

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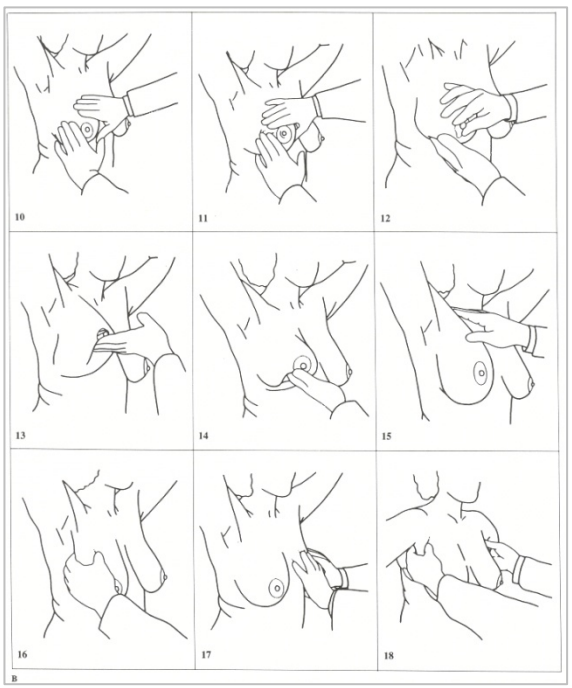
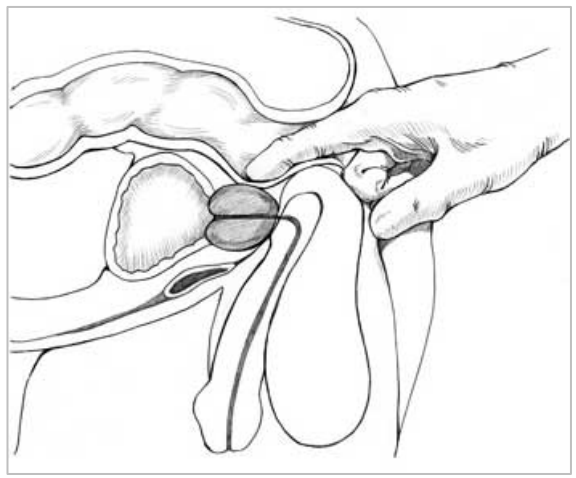
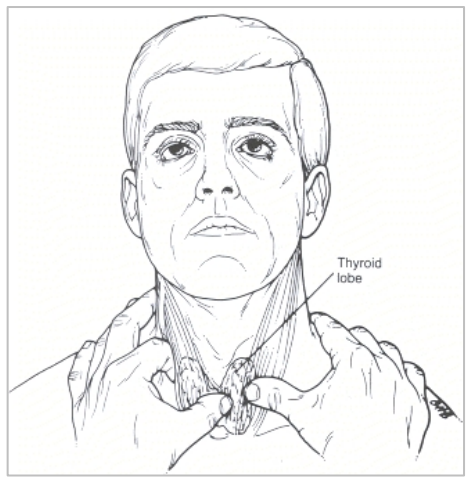
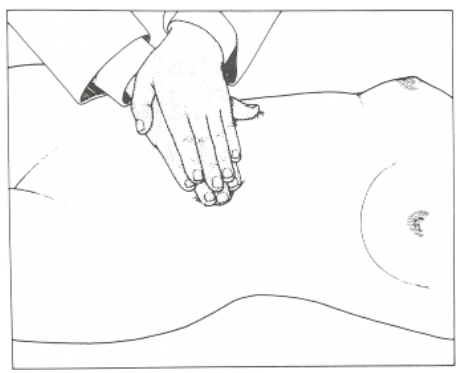
1.3 Background - Manual palpation









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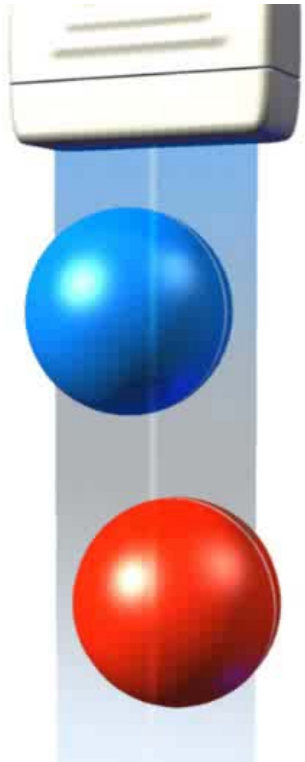
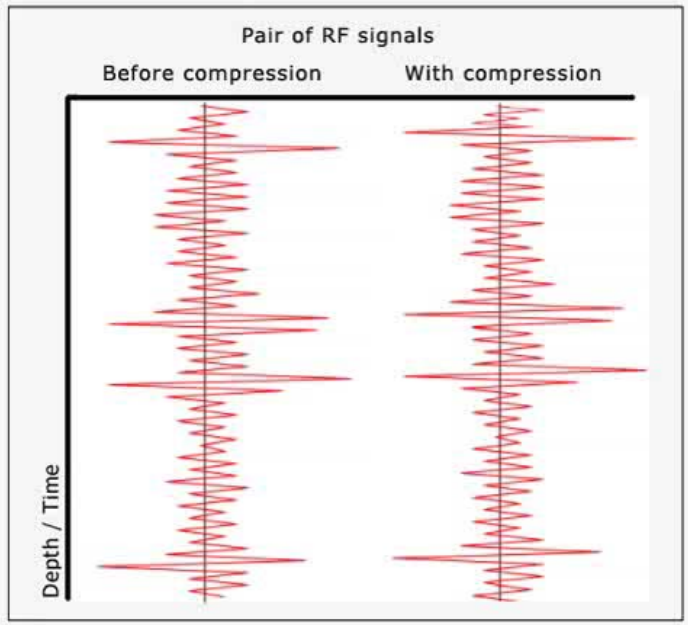
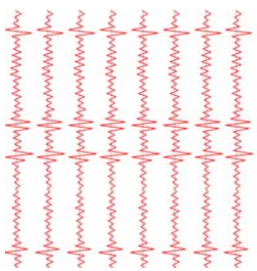


Combined Autocorrelation Method for calculating the strain



Frame 1



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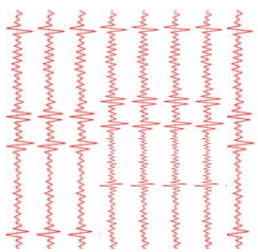
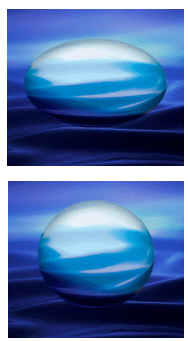
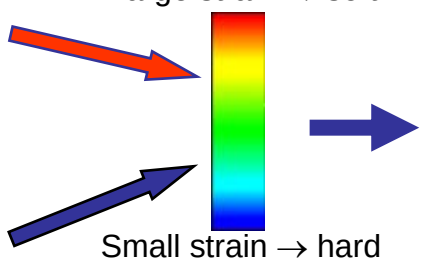
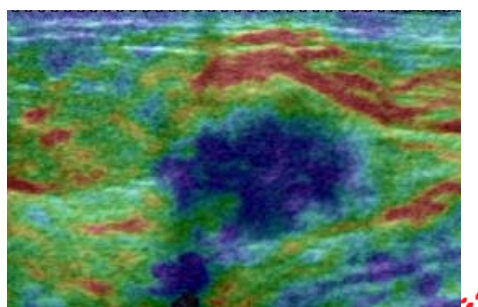




Large strain → soft

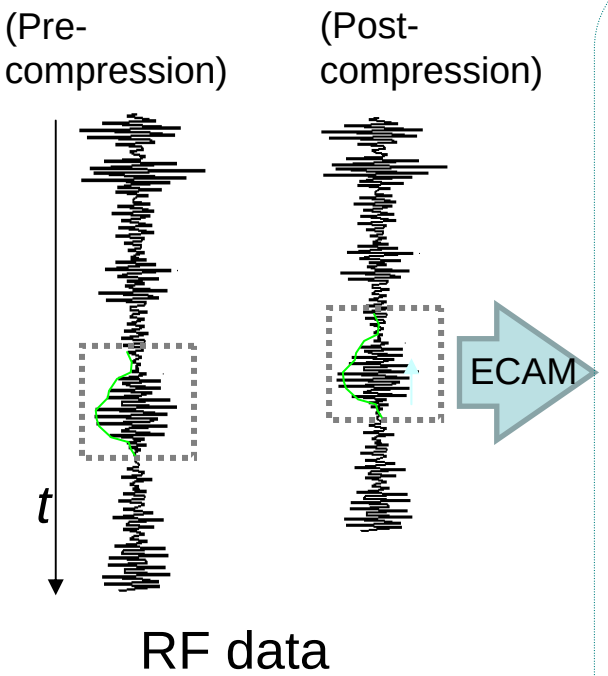


Small strain → hard

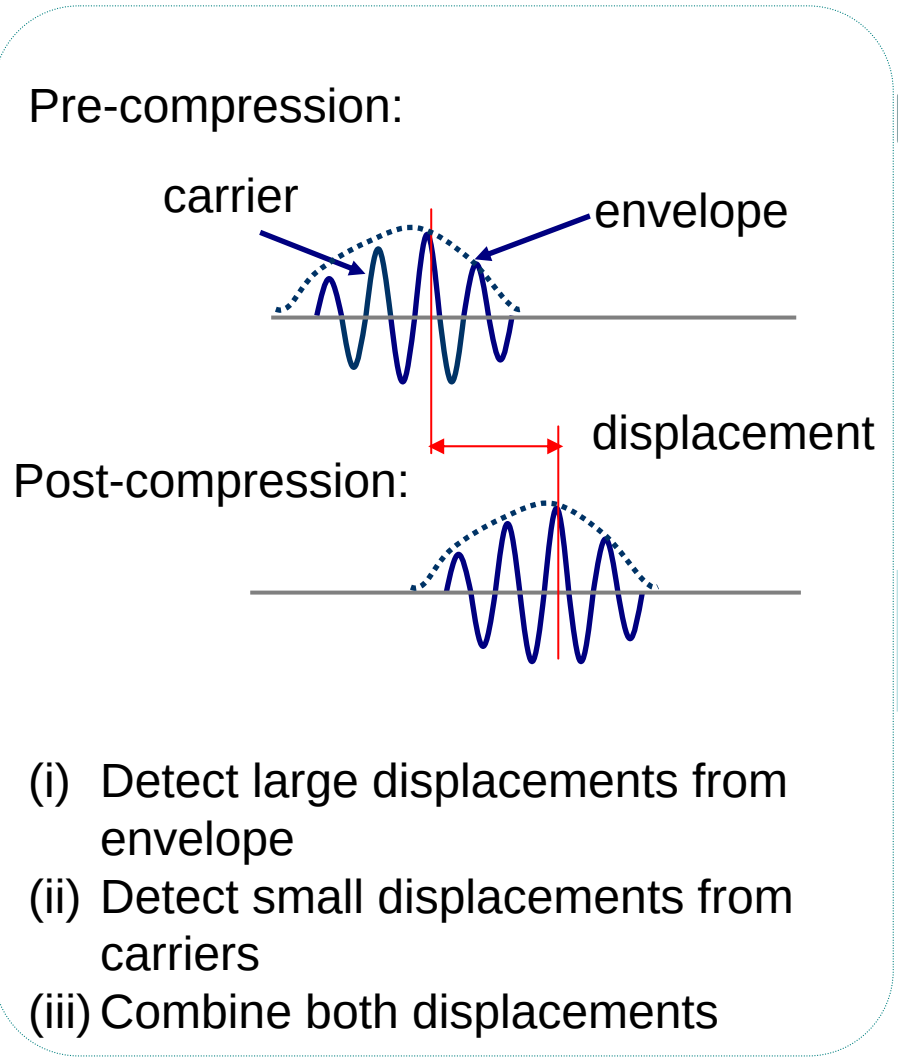


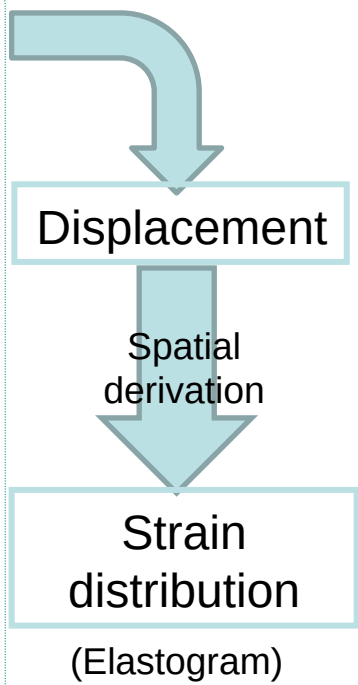
Extended Combined Autocorrelation Method

Strain Estimation Using the Extended Combined Autocorrelation Method, Yamakawa& Shiina, Jpn.J.Appl. Phys.(2001);40:3872-3876



Correlation process interval :
•Depth direction: 1/2-wave interval
•Lateral direction: Interval of scan lines

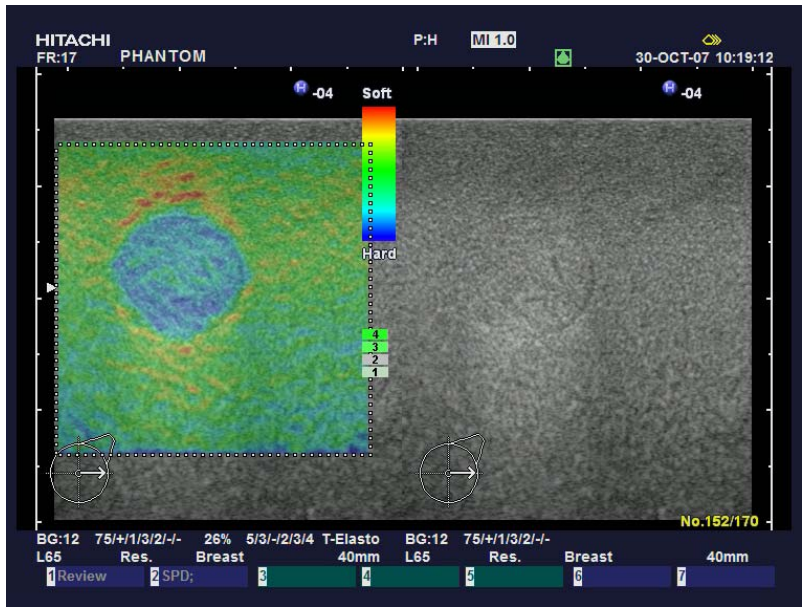


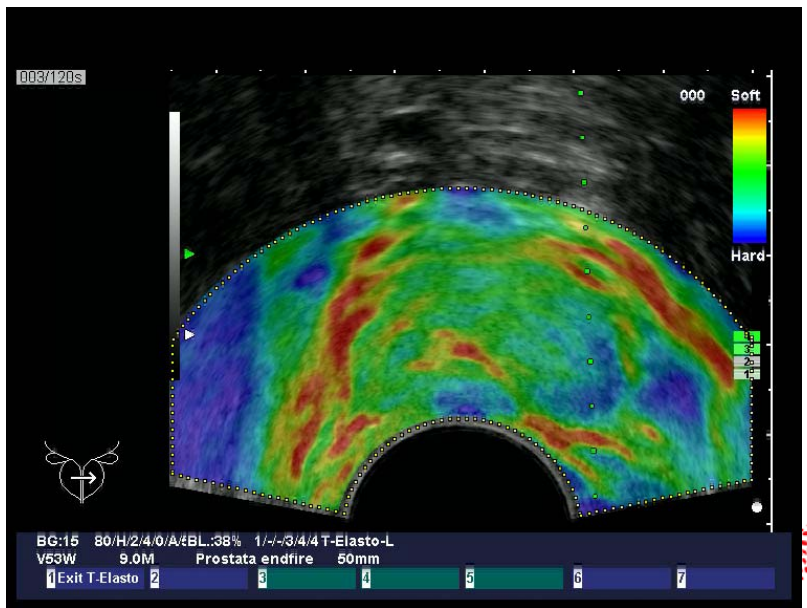


(Elastogram)

Author: E Bibby

- High speed processing
  - display large regions of interest
  - real-time elastography imaging at conventional imaging frame rates
- Images have a wide dynamic range
  - display high contrast between malignant and benign tissue
  - real-time diagnosis
- Algorithm is robust to variations in speed or degree of compression
  - accurate and reproducible with a freehand technique





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1.7 Advantages of compression elastography

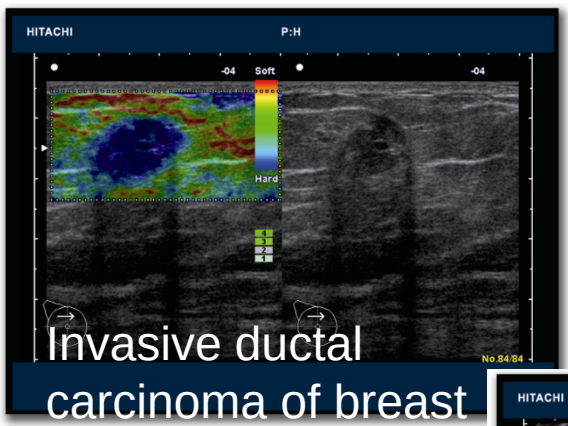
- Technique is simple, intuitive
- Accurate and reproducible with a significant amount of published data:

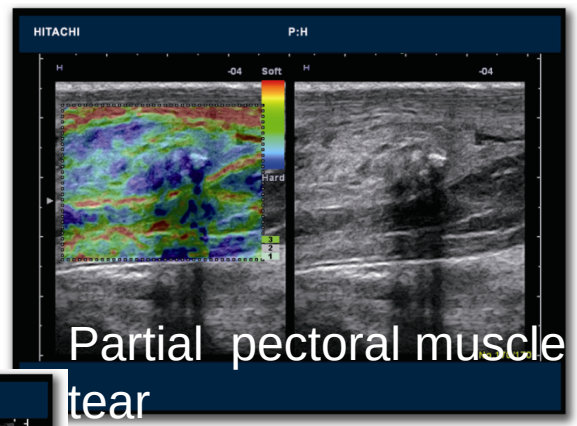
- HI-RTE Italian multicentre study: 8 centres, 874 breast lesions,
  - Kappa score for intra-observer variability = 0.93, inter-observer variability = 0.90
  - (Rizzatto G**.** Real-time breast sonoelastography: results of the Italian multicenter study (874 cases). Radiological Society of North America 93rd Scientific Assembly and Annual Meeting November 25th – 30th, 2007, Chicago, USA)

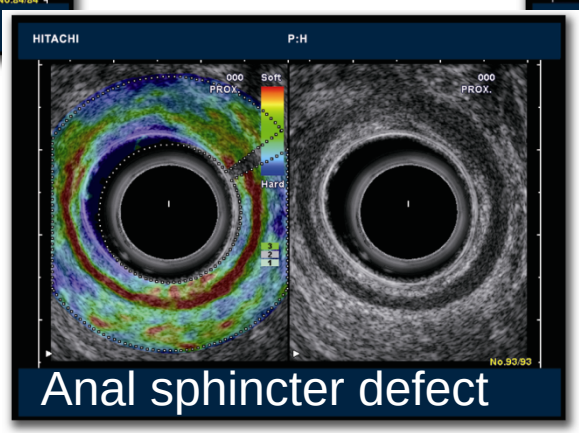
- European multicentre study: 6 centres (15 operators), 429 breast lesions,
  - Kappa score for intra-observer variability = 0.8, inter-observer variability= 0.73
  - (Schafer F., Athanasiou A., Leconte I., et al. Ultrasound elastography: results of a European multicentric study of 429 breast lesions. European Congress of Radiology, March 7th – 10th 2008, Vienna, Austria)

- Can be added to a conventional ultrasound machine, and so is easily incorporated into the routine ultrasound examination and available at all price levels

- The simultaneous real-time display gives the operator the anatomical correspondence between tissue elasticity and the B-Mode image
- Stiffer structures are displayed in blue as this colour allows easier visualisation of grey scale image behind the transparent colour overlay







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1.10 Advantages of compression elastography

- HI-RTE compression elastography is made available on a full range of transducers – linear/convex/ endocavity/endoscopes /laparoscope/intra-operative transducers

Endocavity
(Example EUP-R54AW)

Echo endoscopes
(Example EG-3670URK)

Linear Arrays
(Example EUP-L74M)

Laparoscopic
(Example EUP-OL-531)

Convex Array
(Example EUP-C532)

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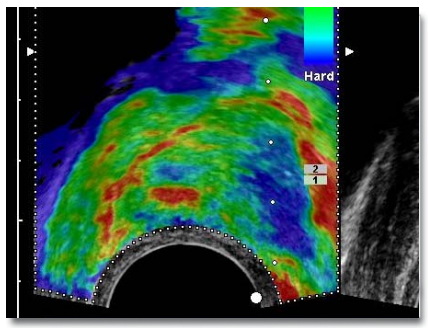
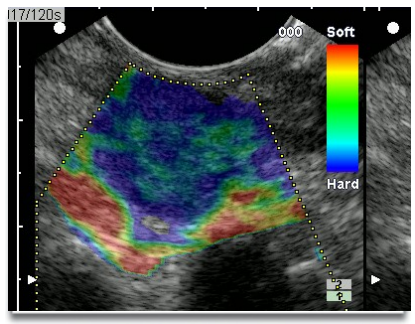
1.11 Advantages of compression elastography

- HI-RTE compression elastography is made available on a full range of transducers – linear/convex/ endocavity/endoscopes /laparoscope/intra-operative transducers
- Applications in clinical areas such as the breast, prostate, thyroid and pancreas, and many more

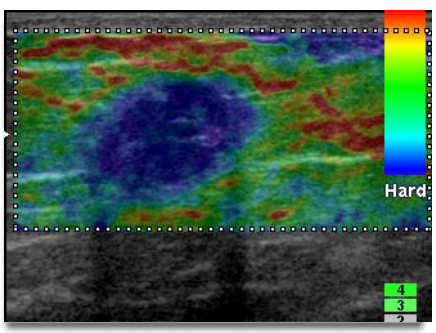
Endocavity
Prostate carcinoma



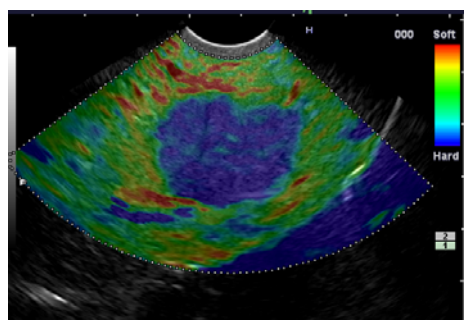
Echo endoscopes
Malignant lymph node



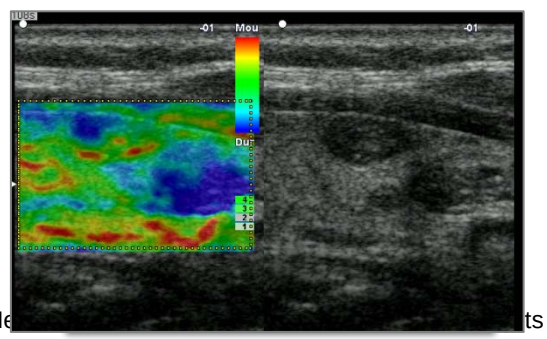
Linear Array
Breast carcinoma



Laparoscopic
Liver tumour

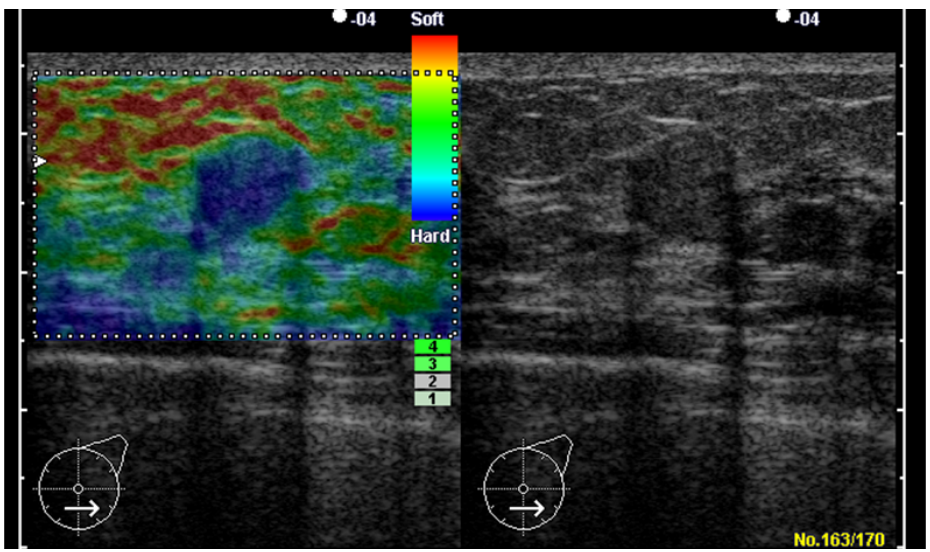


Linear Array
Thyroid tumour

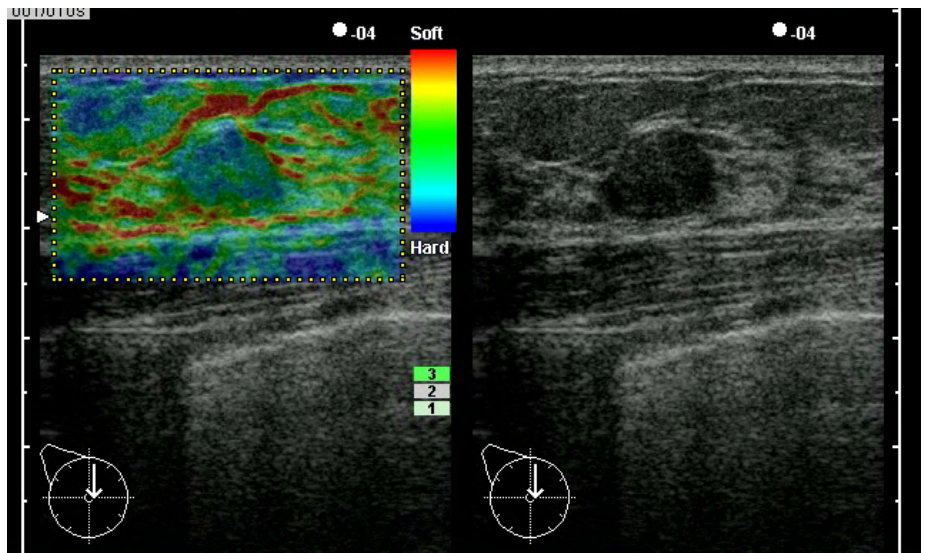


HI-RTE
Hitachi Real-time Tissue Elastography

- Elastography when combined with B-mode ultrasound
  - ➢ increases the specificity of the examination
  - ➢ offers the potential to reduce the number of diagnostic biopsies
- Elastography assessment has potential to re-classify lesions ‘indeterminate’ on mammography and conventional ultrasound (BI-RADS 3 & 4)
  - – An example of two different lesions with a similar round shape; both are hypoechoic on conventional ultrasound:



Invasive ductal carcinoma



Fibroadenoma

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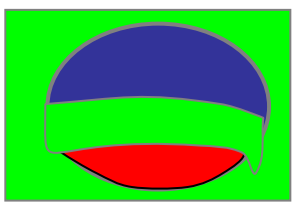
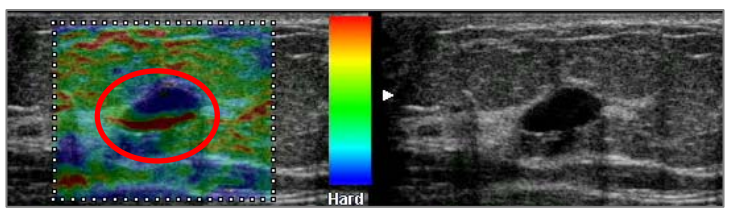
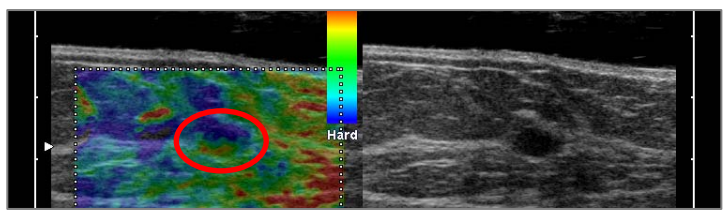
- Published prospective studies have shown comparable results:
  - Elastography increased the specificity of B-mode ultrasound (85% to 98.5%)
  - Increased the positive predictive value while slightly lowering or not affecting the sensitivity (78% to 87%).
  - Itoh A, 2006; Thomas A, 2006; Tardivon A, 2007; Zhi H, ;Tan, 2008

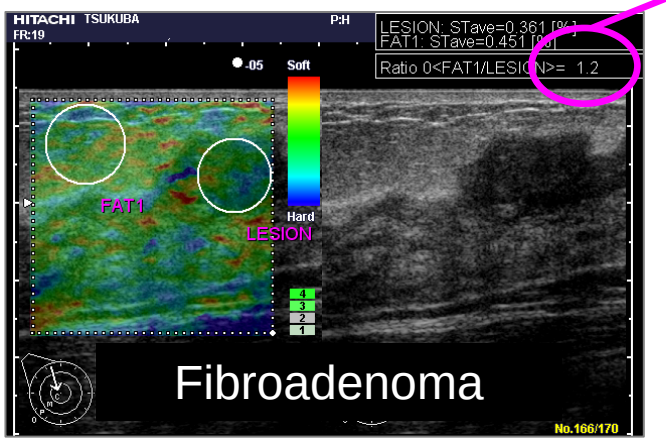
- The three-layered elastography appearance of a breast lesion may be considered as a reliable sign of cyst.
  - Accuracy 87% (Martegani); Small sized and complicated cysts exhibited a typical three-layered pattern in 87% of the cases, (Locatelli); >70% cases (Tardivon)]



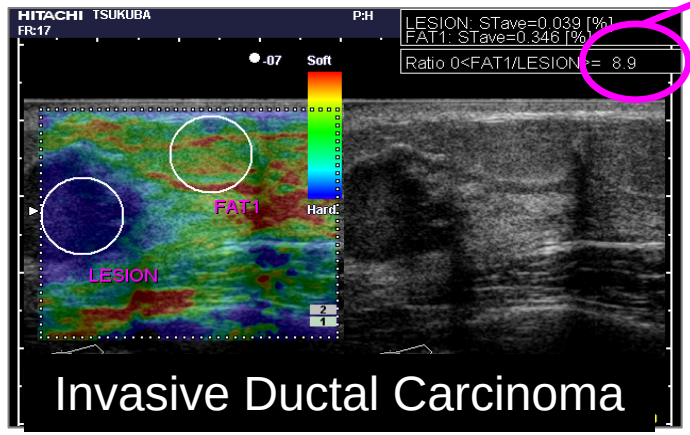




- Greater objectivity and accuracy can be obtained using quantitative measurements, such as Strain Ratio (SR):



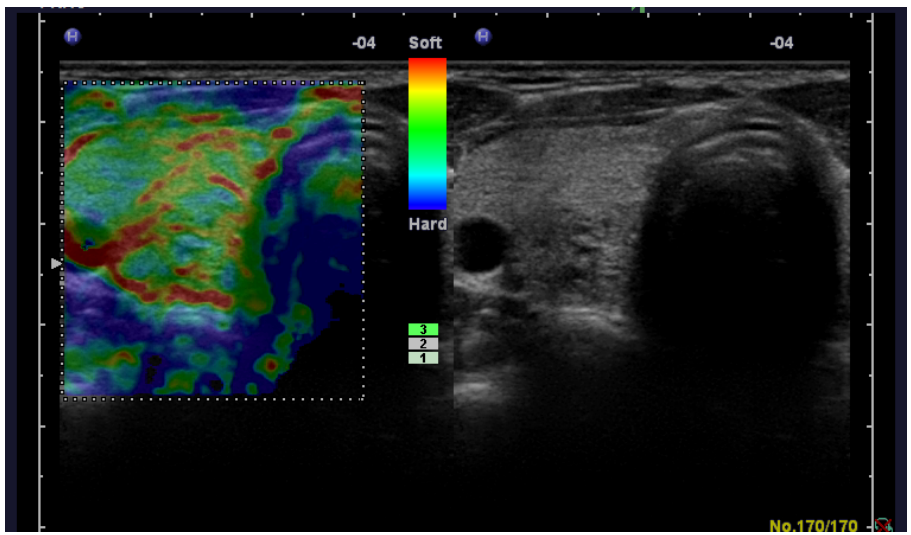
SR = 1.2

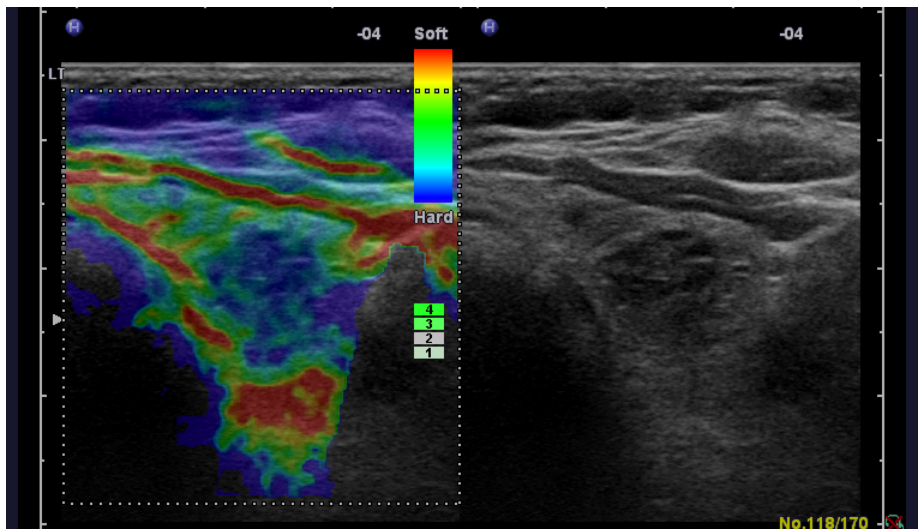


SR = 8.9

- Thomas A. and co-authors: Significant differentiation of focal breast lesions: calculation of strain ratio in breast sonoelastography. *Acad Radiol. 2010 May;17(5):558-63.*
  - SR had a positive predictive value of 89%, which was superior to B-mode scanning (68%) and qualitative elastography (84%).
- ECR 2010: Strain ratio measurement method: A more objective breast lesion diagnosis method with UE, H. Zhi, et al
  - The AUC of the strain ratio measurement method was 0.944; the AUC of the 5-point scoring system was 0.885.

- In the thyroid, stiff areas that are blue on elastography images are highly predictive of malignancy.
- Nodules that are completely elastic have a low risk of malignancy (Rubaltelli L, 2009; Rago T, 2007; Vorländer C, 2010)
  - Potential to decrease number of FNAs
  - Effective tool for identifying and targeting focal stiff nodules for biopsy especially in multinodular goitre.





Small, poorly defined heterogenous nodules – one soft on elastography, other lesion with similar appearances on grey scale but is suspicious for malignancy on HI-RTE evaluation

- In the thyroid, stiff areas that are blue on elastography images are highly predictive of malignancy.
- Nodules that are completely elastic have a low risk of malignancy (Rubaltelli L, 2009; Rago T, 2007; Vorländer C, 2010)
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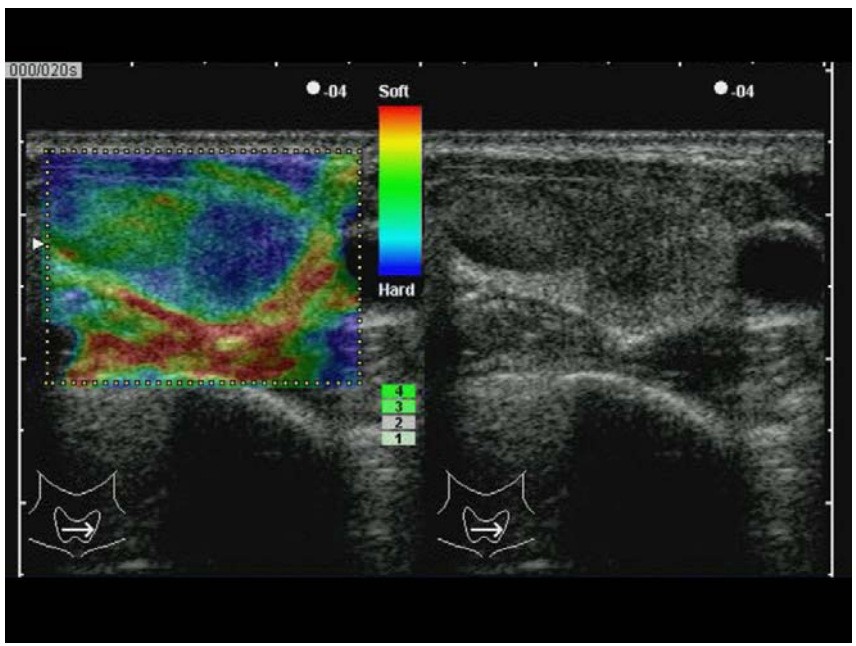

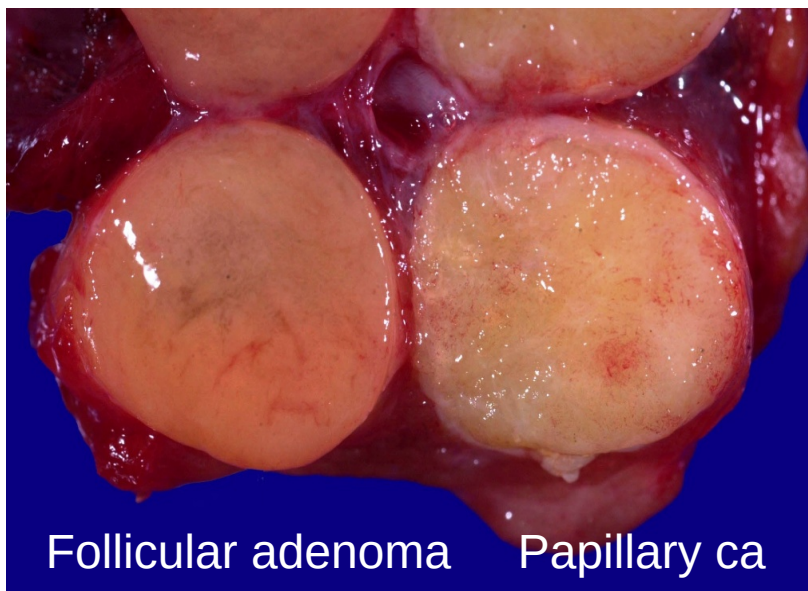

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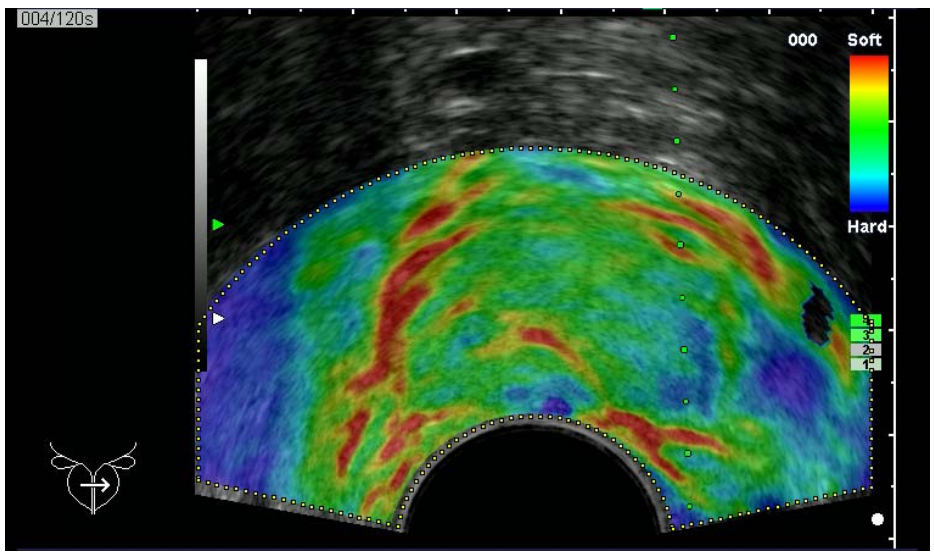
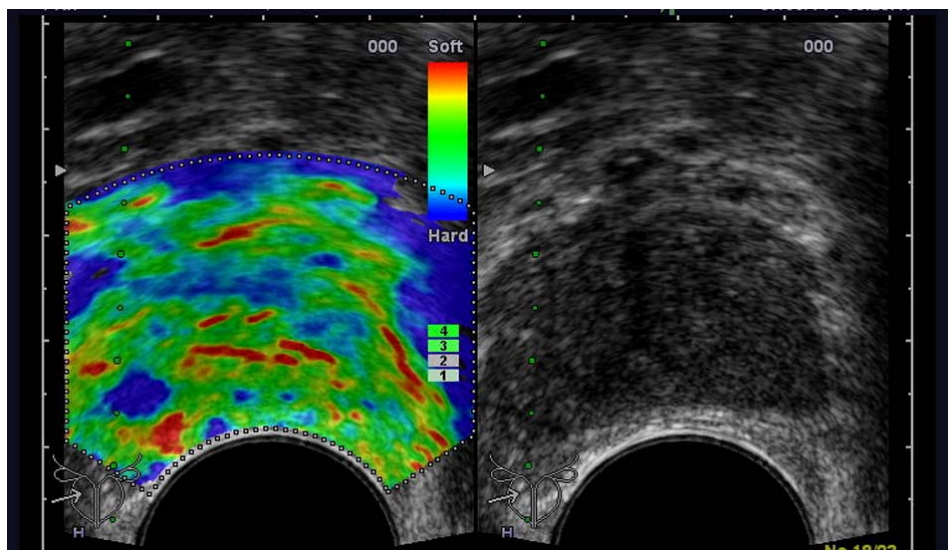
- HI-RTE is capable of visualizing focal deposits of prostate cancer as ‘stiff’ lesions and therefore can be used for detection and for targeting ultrasound guided biopsy. (Salomon G, 2008, Pallwein L, 2007, 2008)
- In addition, HI-RTE can delineate the prostate capsule (the ‘red rim’ sign) and shows good correlation with MRI for predicting extracapsular spread.

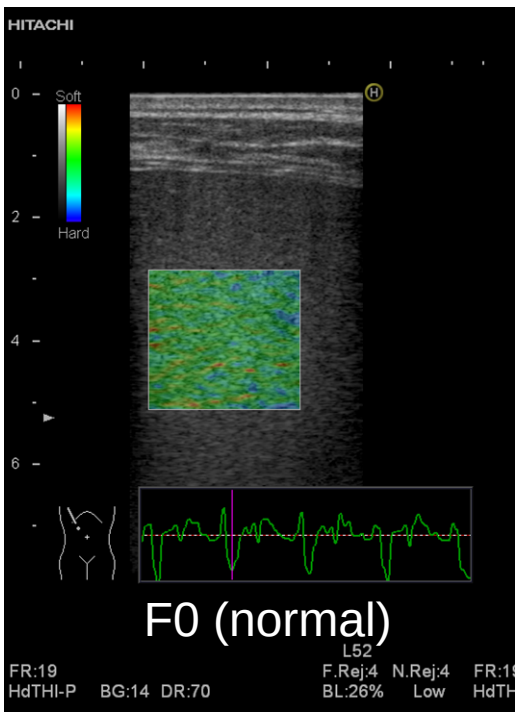


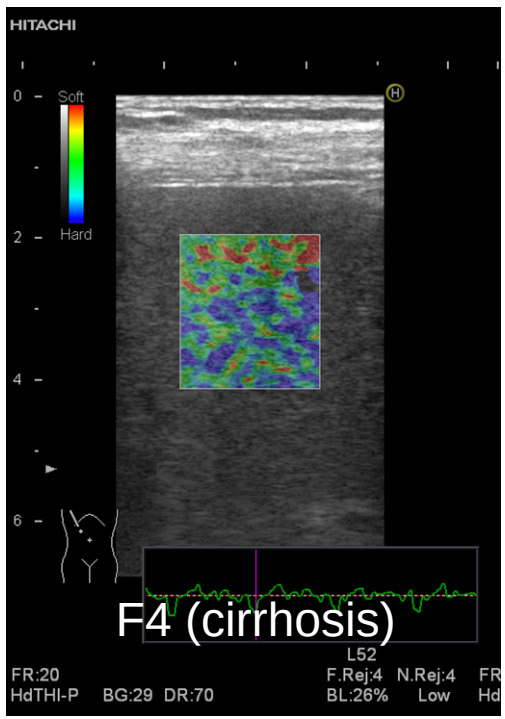
Lesion in left peripheral zone showing loss of overlying prostatic capsule

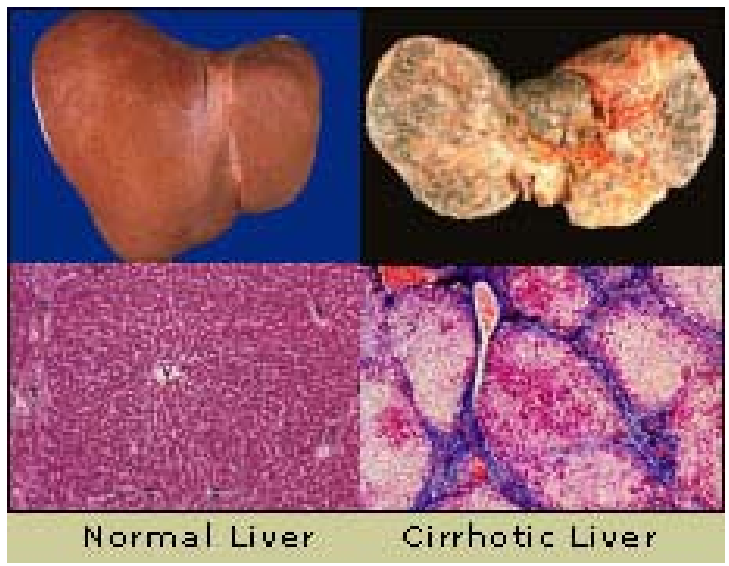


Small discrete lesion on right side, green dotted line indicates the path of biopsy needle

- The availability of a reliable, non-invasive method for detecting liver fibrosis could have a substantial impact on the management of patients with chronic liver disease.
- The HI-RTE strain image becomes patchy, with an increasing number of harder (blue) regions, in patients with fibrosis.







Degree of fibrosis

HI-RTE
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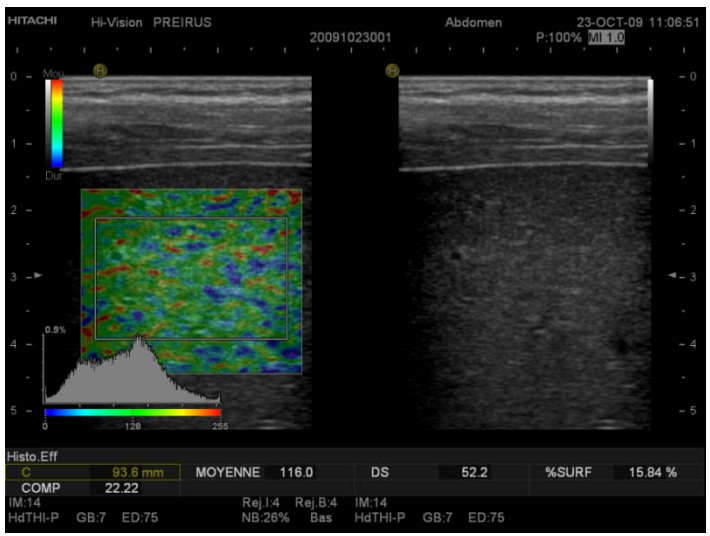
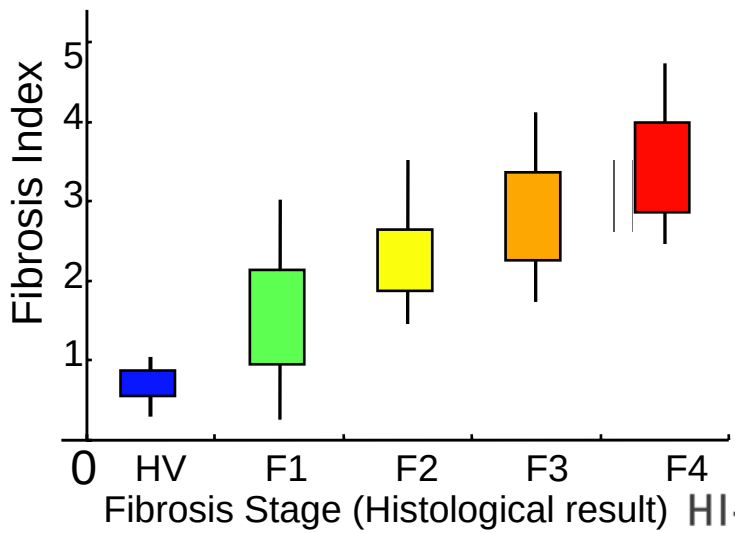
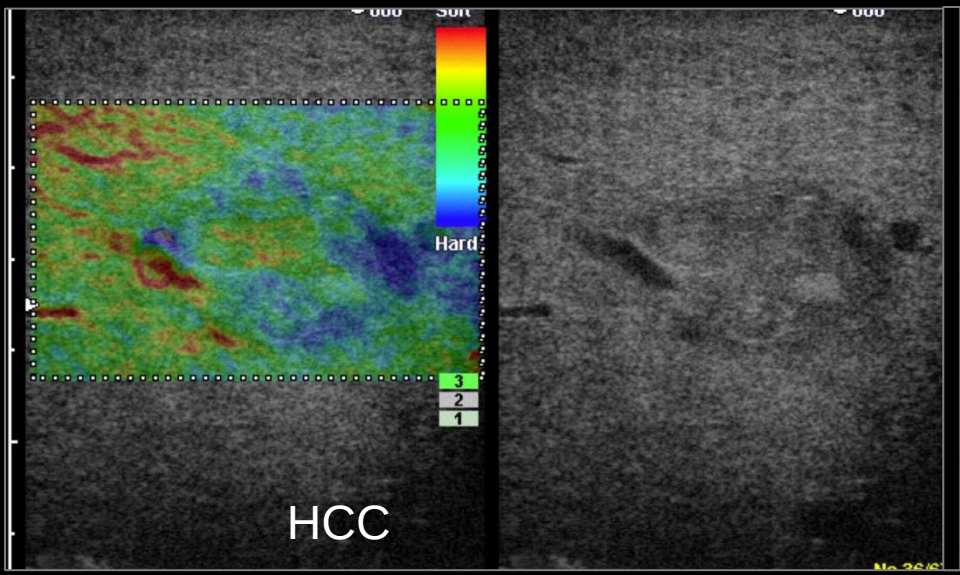
- The availability of a reliable, non-invasive method for detecting liver fibrosis could have a substantial impact on the management of patients with chronic liver disease.
- The HI-RTE strain image becomes patchy, with an increasing number of harder (blue) regions, in patients with fibrosis.
  - Tatsumi C., et al. Non-invasive evaluation of hepatic fibrosis for type C chronic hepatitis. Intervirology. 2010;53(1):76-81.
  - Tonomura A., et al. WFUMB 2009 Image analysis of real-time tissue elastography for evaluation of liver fibrosis progression.
  - Multiple regression analysis performed with these 4 features yielded a RTE fibrosis value, and it highly correlated with the fibrosis stage (r=0.751).



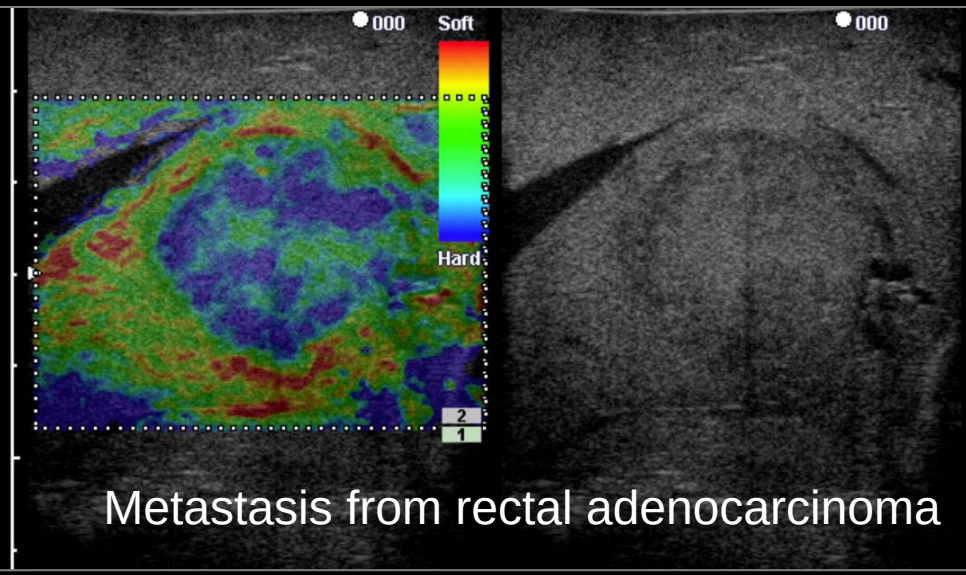


HI-RTE
Hitachi Real-time Tissue Elastography

- Some limited use for characterisation of liver lesions:
  - Intraoperative/laparoscopic approach:



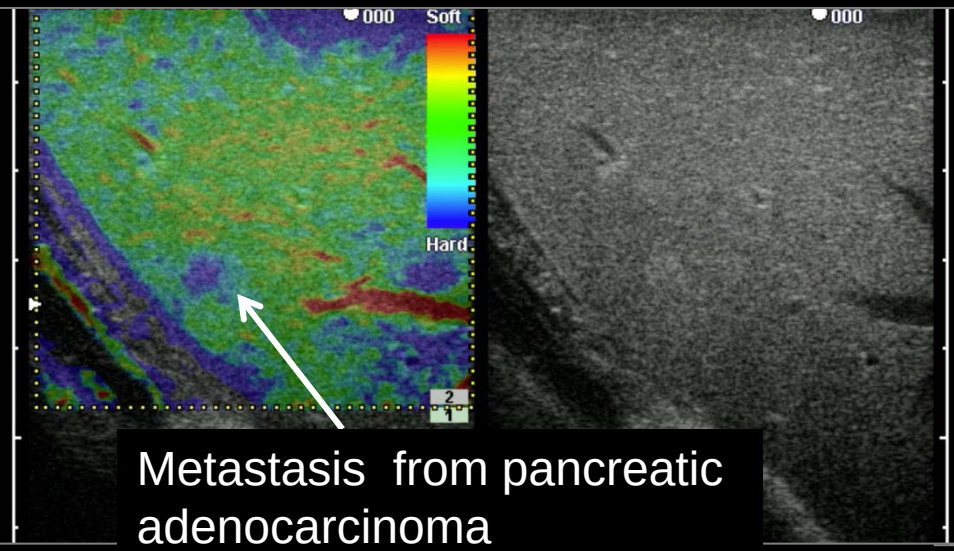
HCC



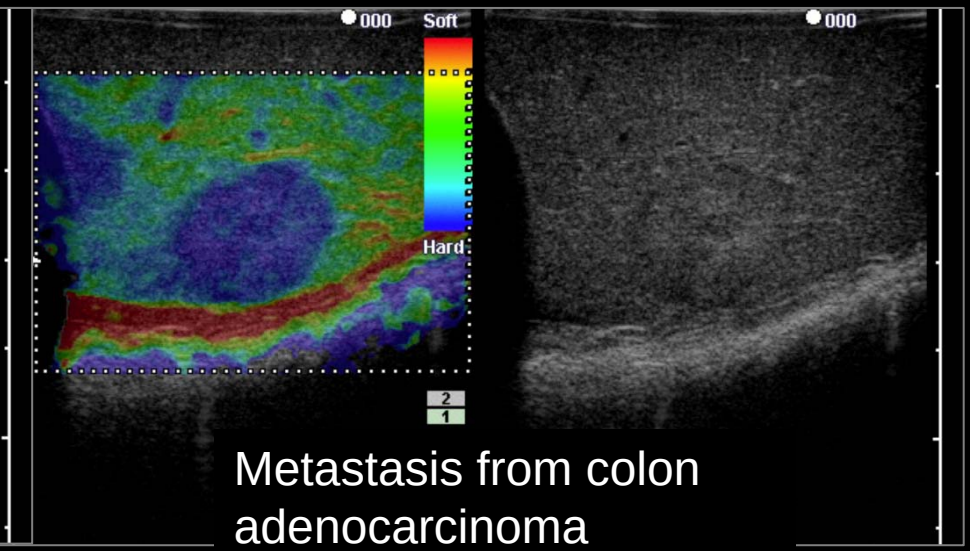
Metastasis from rectal adenocarcinoma

Courtesy of Dr. Katoh and Dr. Sugimoto, Nagoya University Graduate School of Medicine, Nagoya, Japan

- Some limited use for characterisation of liver lesions:
  - Intraoperative/laparoscopic approach:



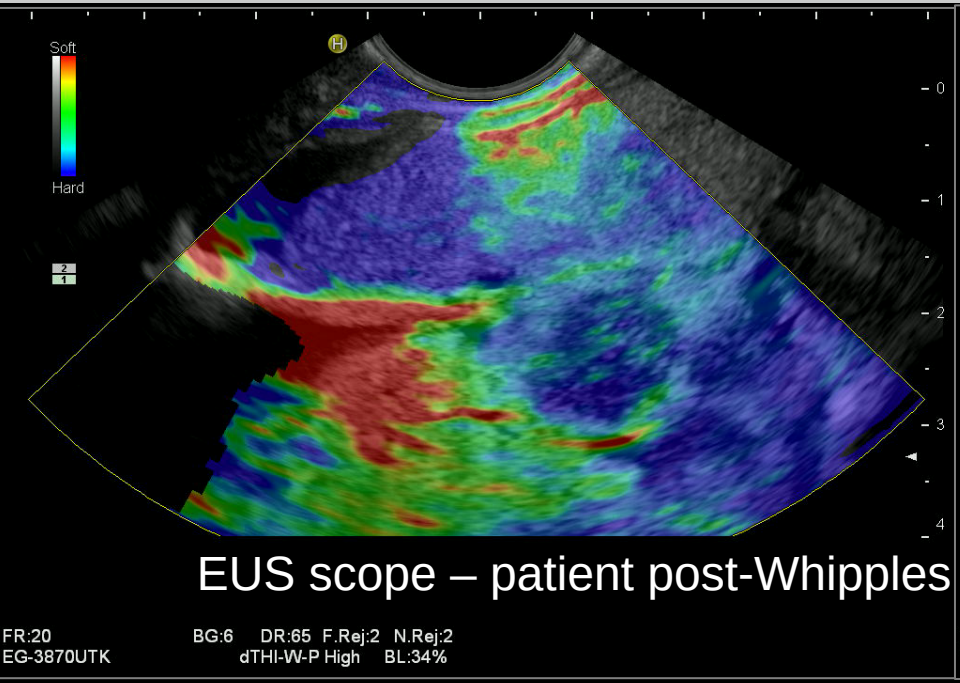
Metastasis from pancreatic adenocarcinoma



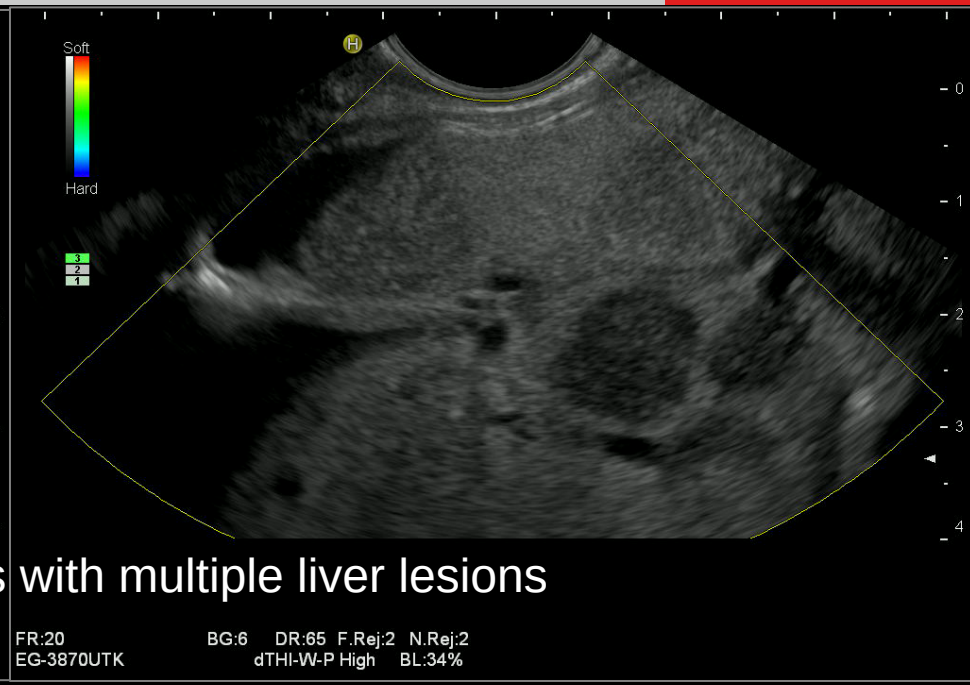
Metastasis from colon adenocarcinoma

Kato K., Sugimoto H., Kanazumi N., et al. Intra-operative application of real-time tissue elastography for the diagnosis of liver tumours. Liver International ISSN 1478-3223

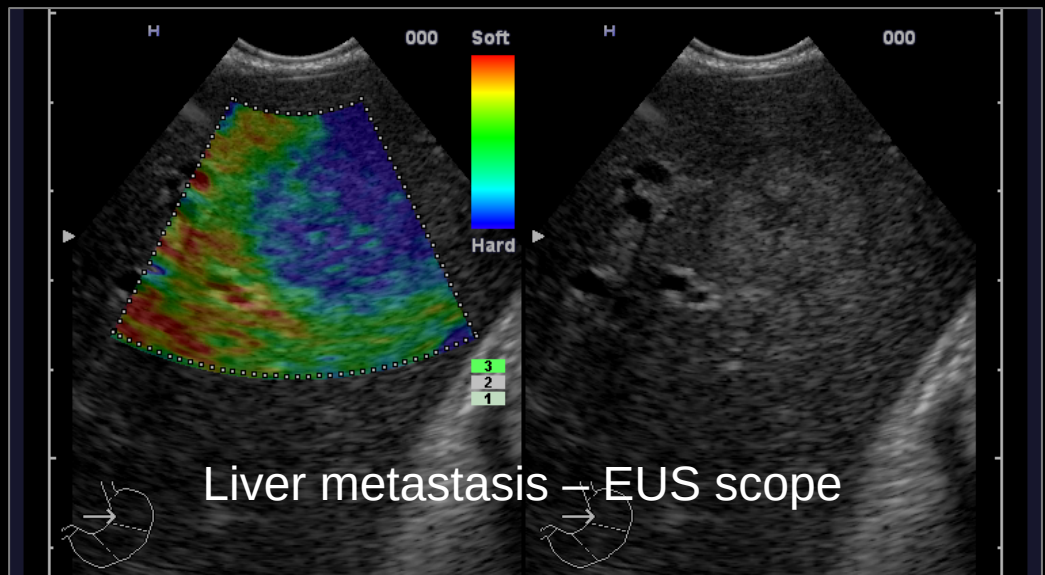
RTE, …enabled us to distinguish rather accurately between two common malignancies: HCC and metastatic adenocarcinoma



EUS scope – patient post-Whipples

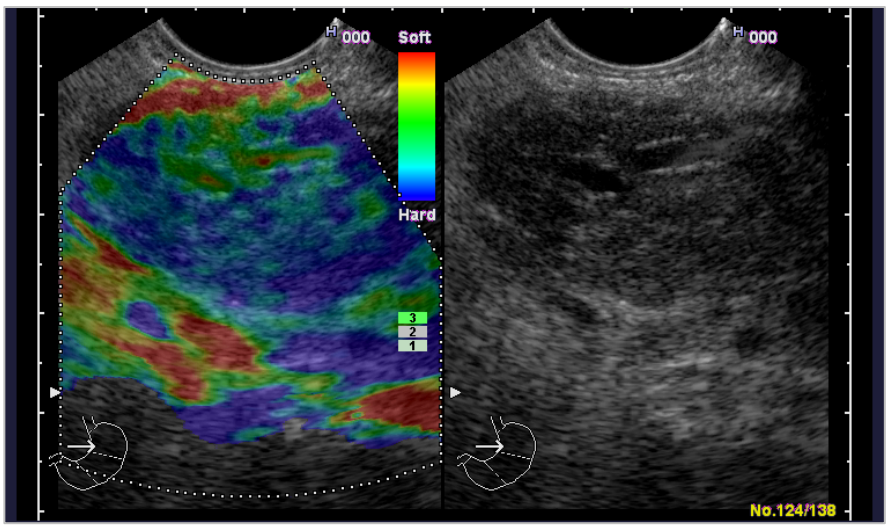


with multiple liver lesions

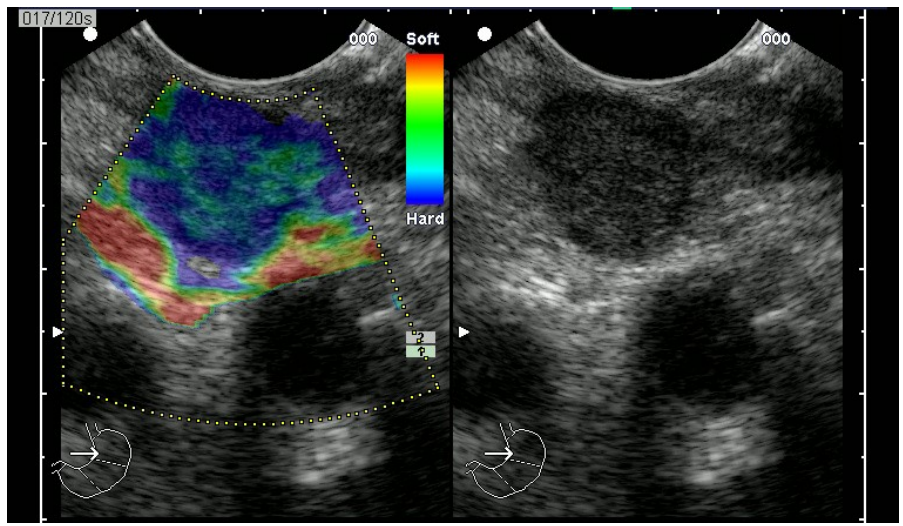


Liver metastasis – EUS scope

- Endoscopic elastography offers additional criteria to help characterize and differentiate the normal pancreas, chronic pancreatitis and pancreatic cancer. (Saftoiu A, 2008, Janssen J, 2007)
- Endoscopic HI-RTE allows characterisation and differentiation of benign and malignant lymph nodes with a high sensitivity, specificity and accuracy. (Saftoiu A, 2008)



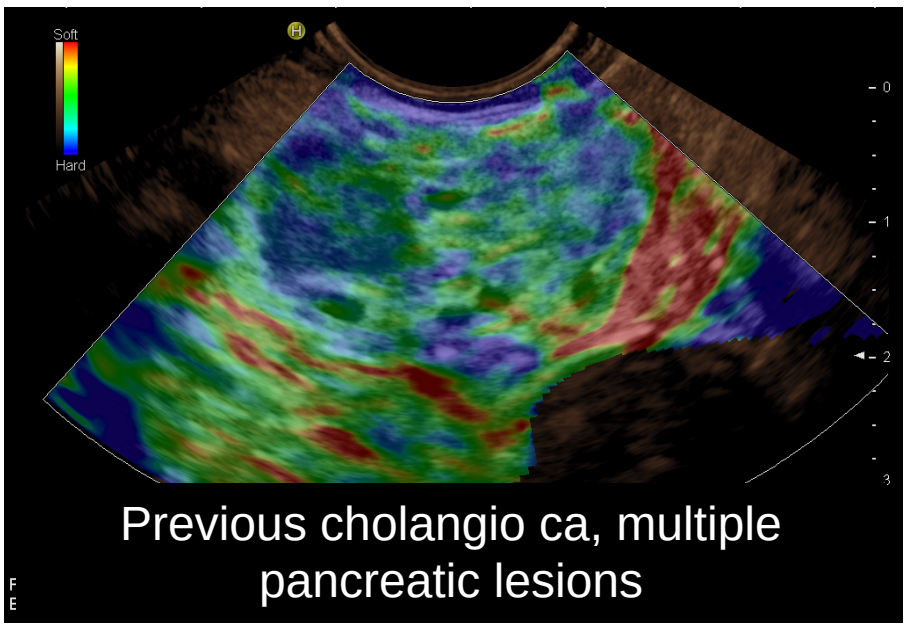
Large pancreatic cancer with some necrotic areas



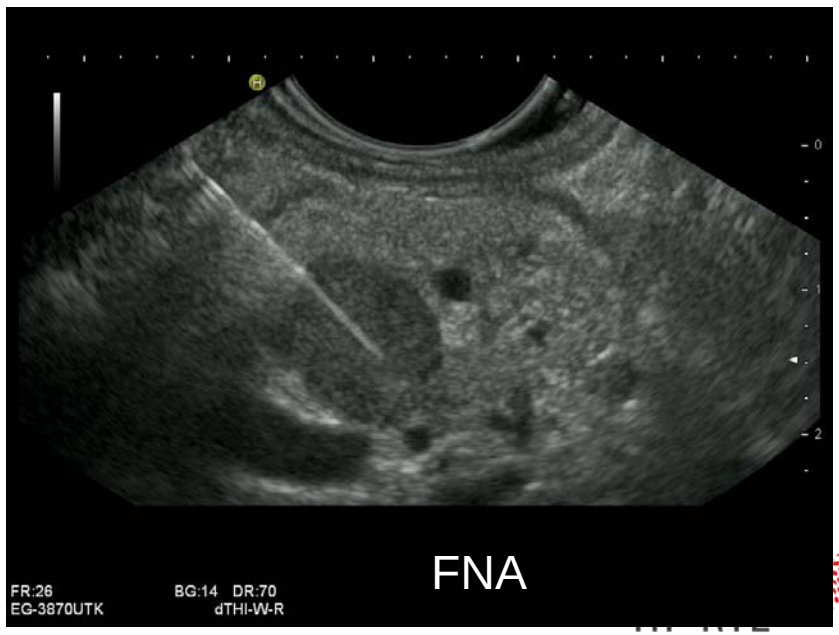
Upper mediastinal malignant lymph node

Author: E Bibby

- Endoscopic elastography offers additional criteria to help characterize and differentiate the normal pancreas, chronic pancreatitis and pancreatic cancer. (Saftoiu A, 2008, Janssen J, 2007)
- Endoscopic HI-RTE allows characterisation and differentiation of benign and malignant lymph nodes with a high sensitivity, specificity and accuracy. (Saftoiu A, 2008)
- The most promising role for this technique is for targeting EUS-guided FNA biopsy into hard regions suspicious of malignancy and for excluding cancer in patients with low probability.



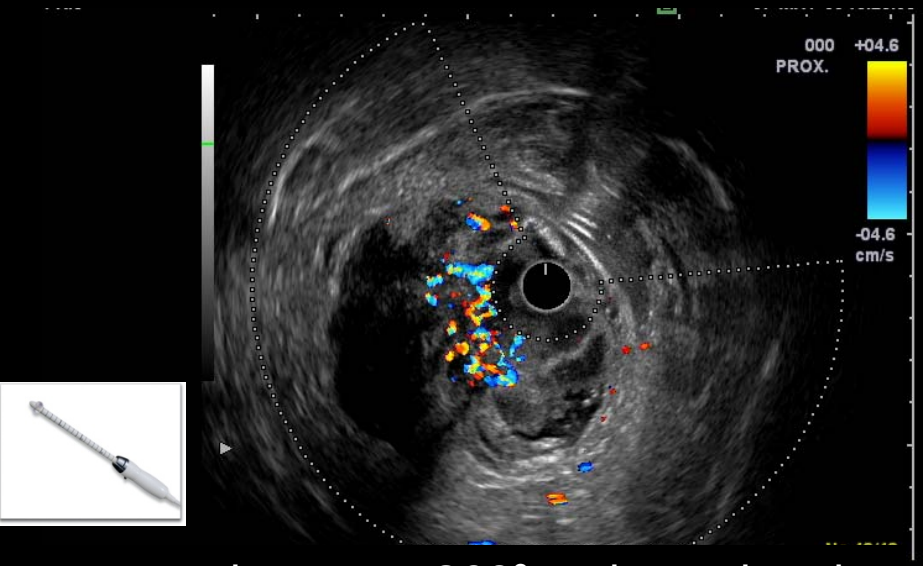
Previous cholangio ca, multiple pancreatic lesions



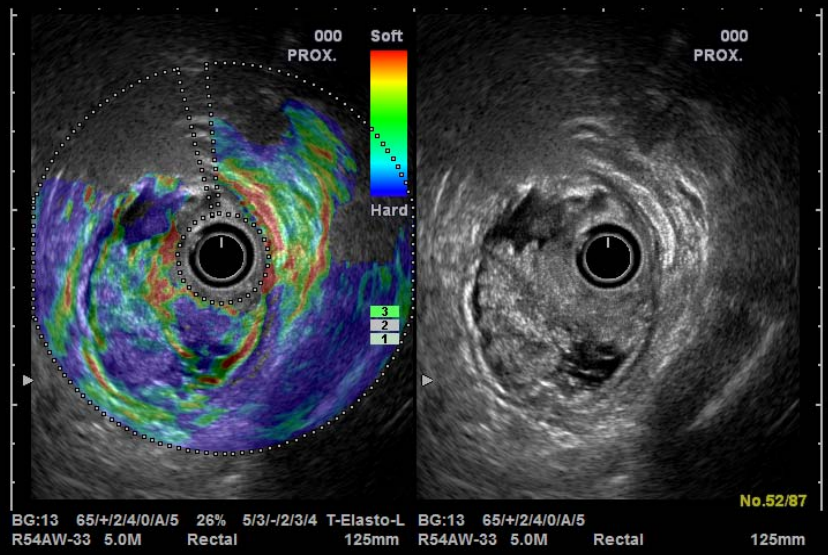
FNA

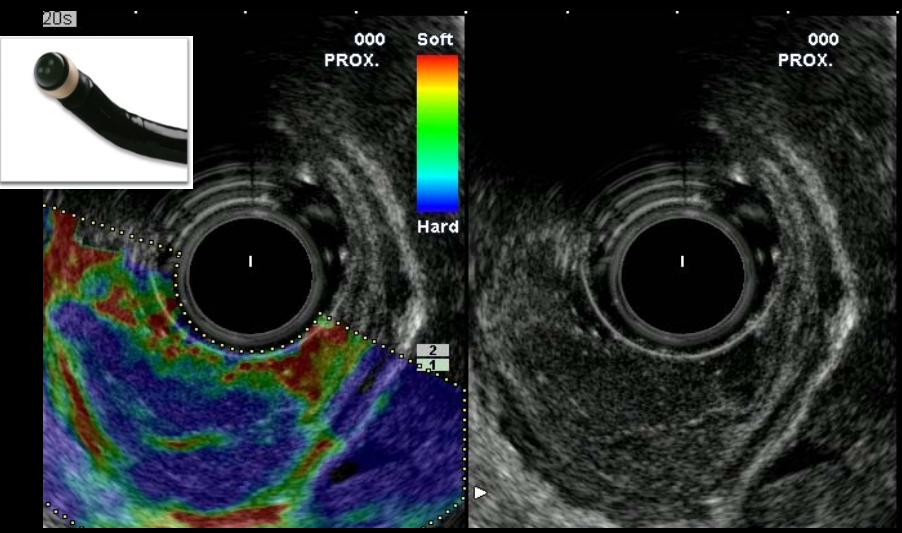
Hitachi Real-time Tissue Elastography

Author: E Bibby

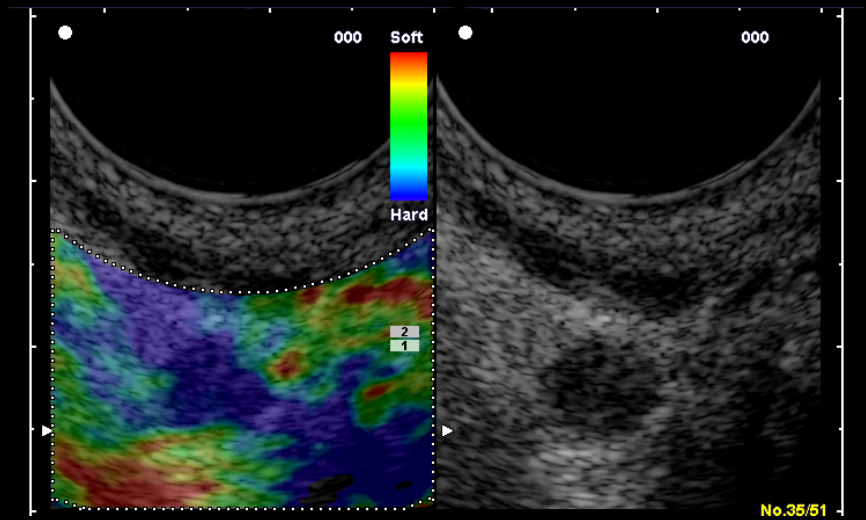


T1 rectal tumour- 360º endo anal probe

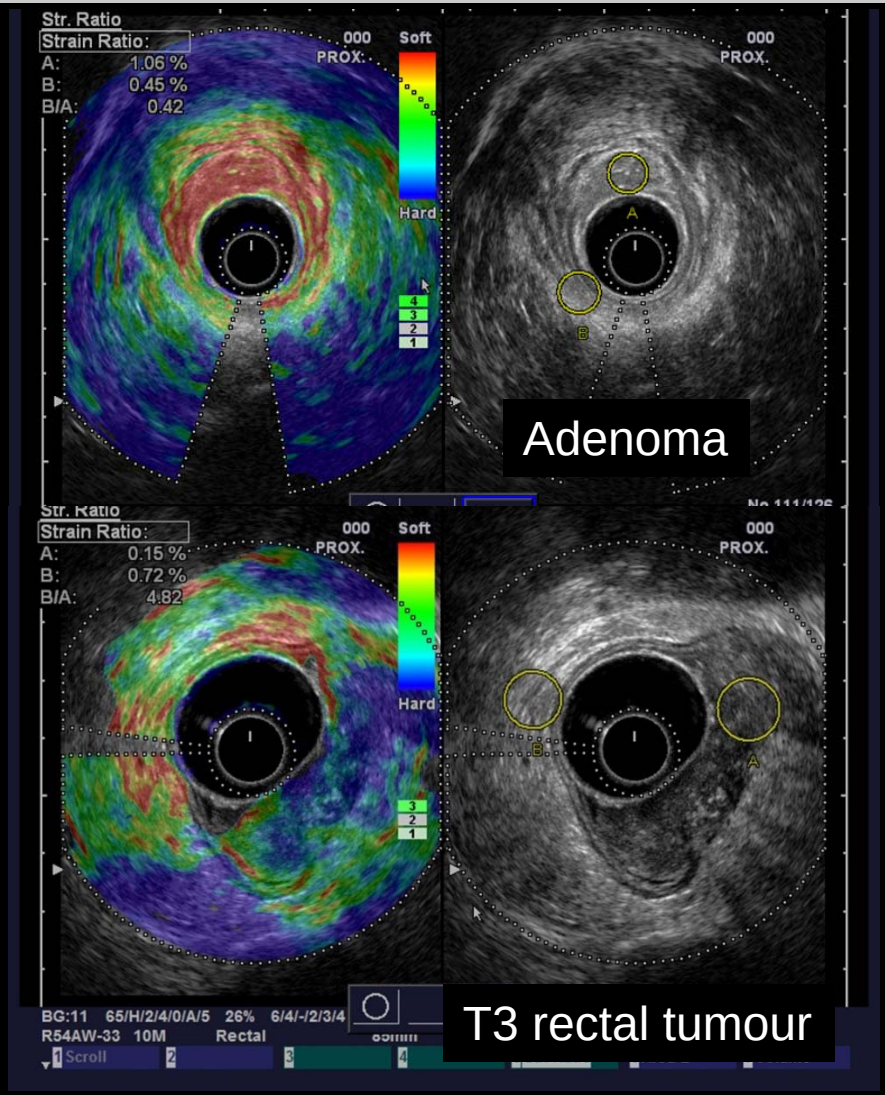


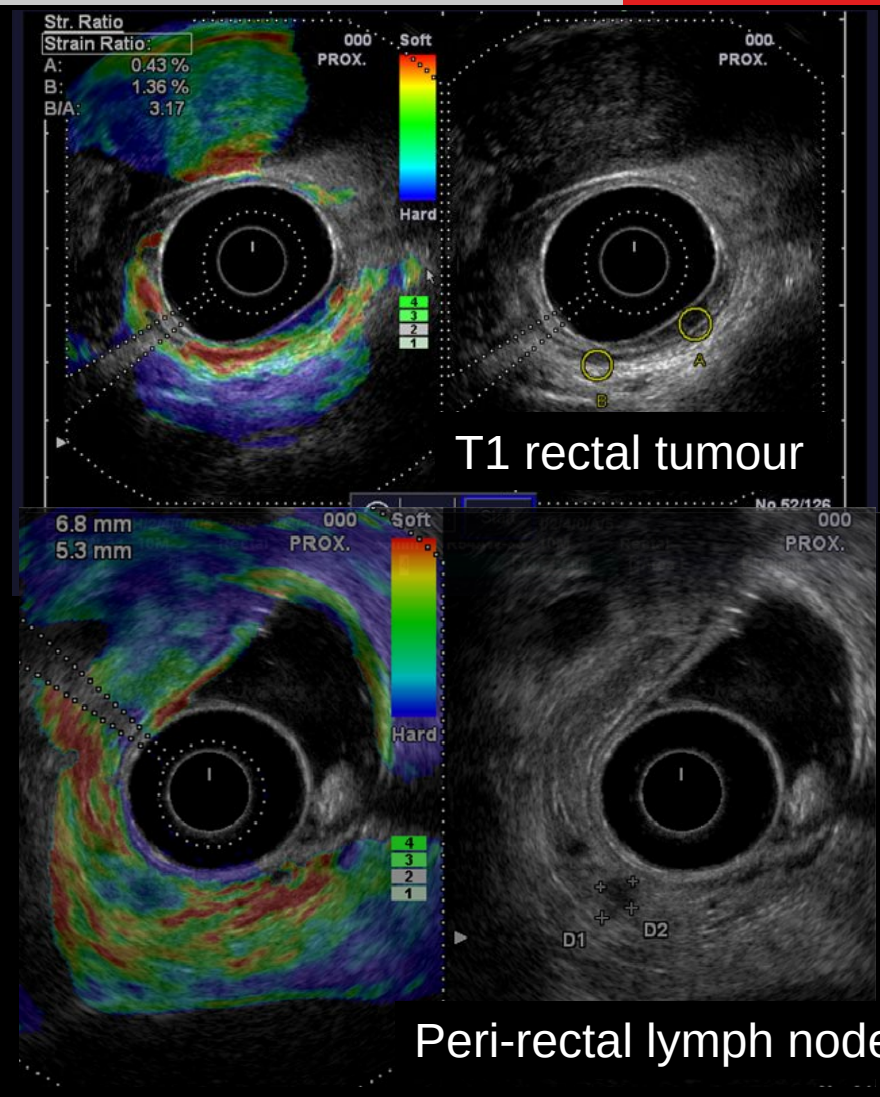


T2 rectal tumour- 360º radial scope



Lymph node infiltration





Endorectal sonography for the evaluation of rectal tumours and peri-rectal lymph nodes
Waage, J (Euroson 2010, Copenhagen)

Summary

- Real-time elastography is a simple, intuitive, real-time technique that can easily be incorporated into the routine ultrasound examination
- When combined with B-mode imaging, Improves the differentiation between benign and malignant disease in variety of clinical applications
- Where intervention is indicated, elastography can be used to improve the accuracy of tissue sampling

Thank you for your attention!

Hitachi Real-time Tissue Elastography

07/09/2010

Hitachi Medical Systems Europe

European Product Manager, Radiology Ultrasound

Ellison Bibby