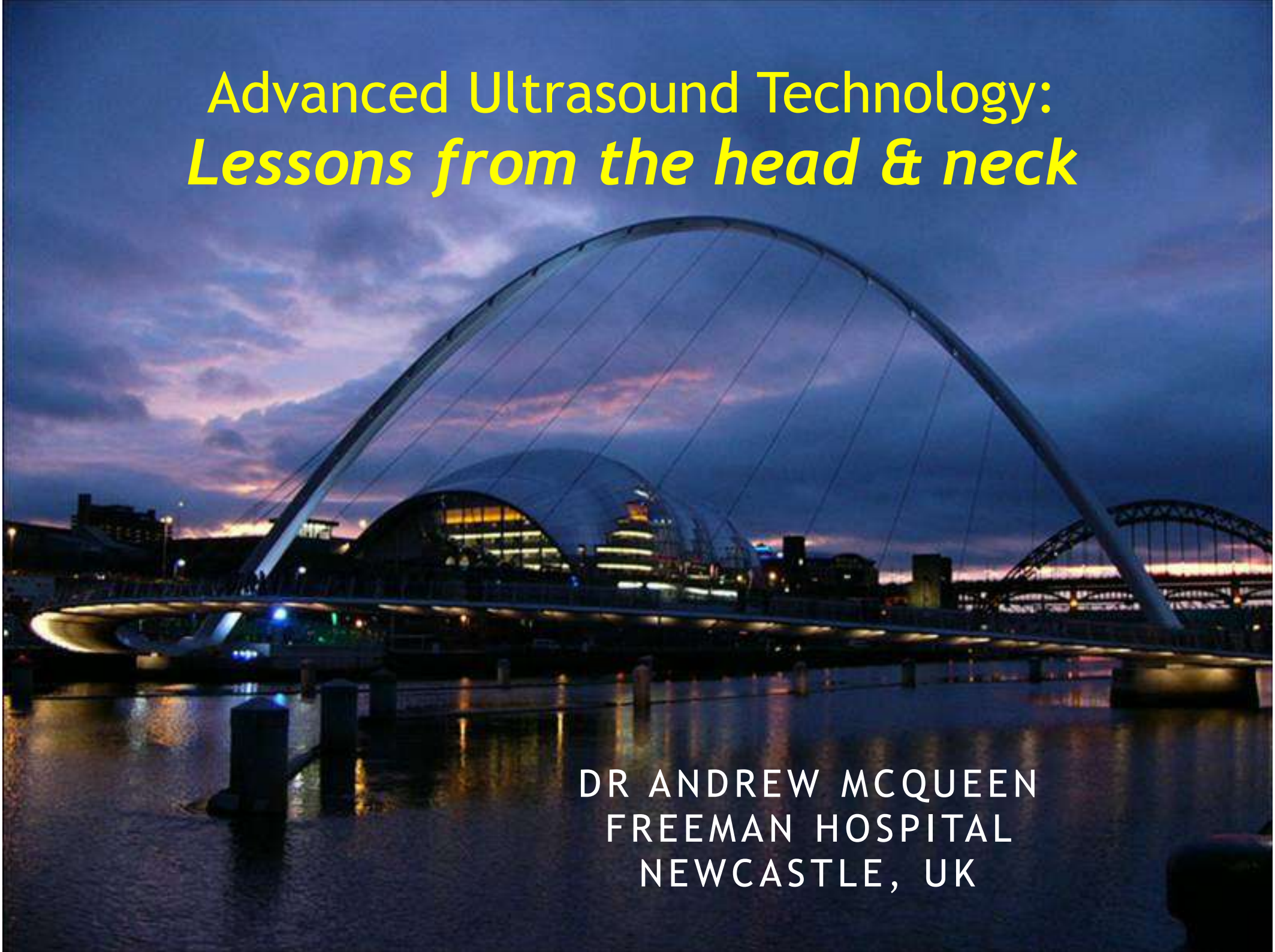
Advanced Ultrasound Technology:
Lessons from the head & neck

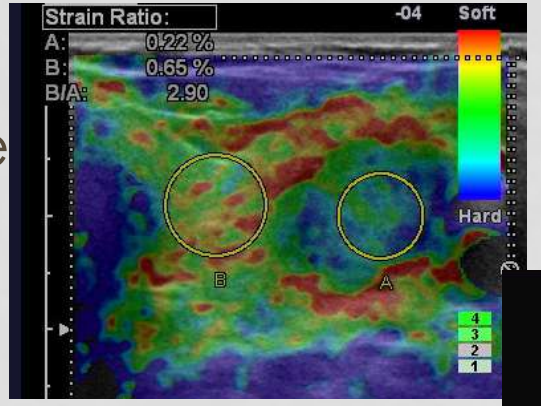


DR ANDREW MCQUEEN
FREEMAN HOSPITAL
NEWCASTLE, UK

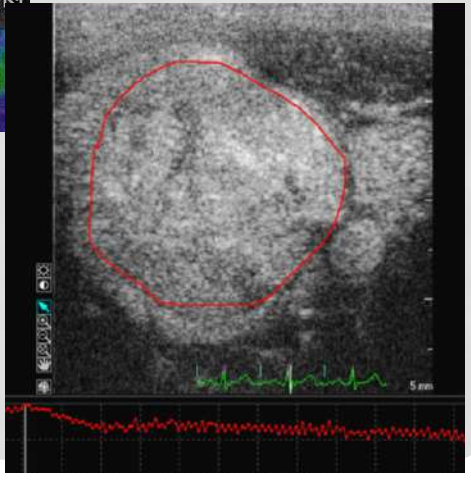
ADVANCES IN ULTRASOUND TECHNIQUE

- High resolution ultrasound
  - Accurate predictors of malignancy & benignity in the neck
  - Pitfalls & technical considerations
  - Novel applications in the neck

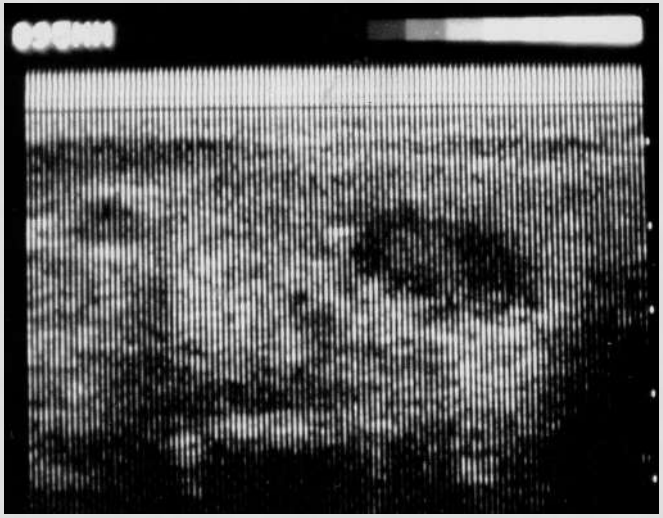
- Ultrasound Elastography
  - Overview of techniques & evide base in the neck



- Emerging roles & new ideas
  - Transoral US
  - Perfusion & Contrast enhanced US
  - The rise of AI..

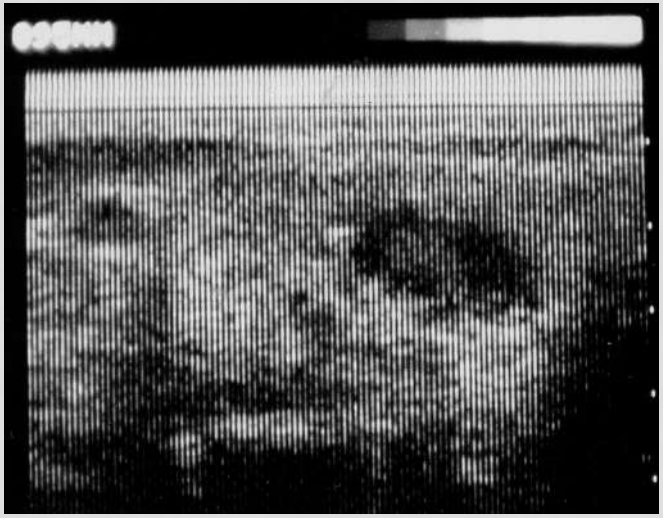


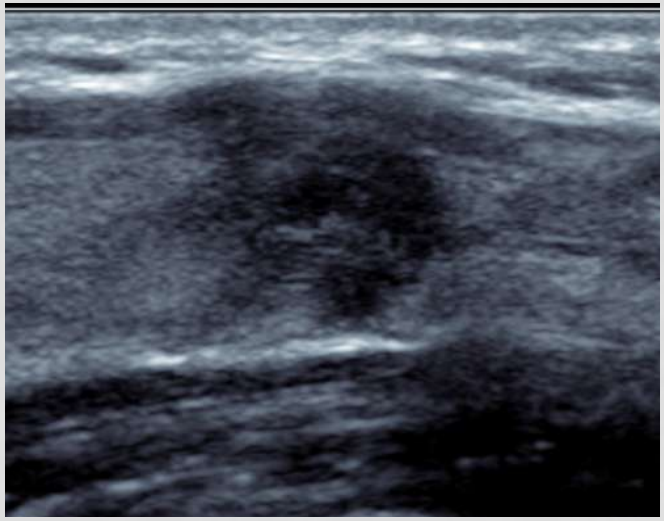
HIGH RESOLUTION THYROID US



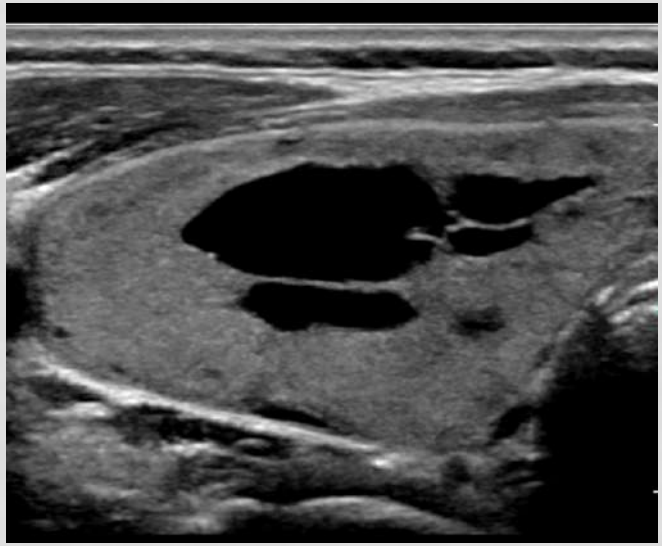
1981: 5MHz linear array

HIGH RESOLUTION THYROID US





1981: 5MHz linear array



HIGH RESOLUTION, BIG DATA..

An Ultrasound Model to Discriminate the Risk of Thyroid Carcinoma

José Miguel Domínguez, MD, René Baudrand, MD, Jaime Cerda, MD, Claudia Campusano, MD, Carlos Fardella, MD, Eugenio Arteaga, MD, Francisco Cruz, MD, Antonieta Solar, MD, Tatiana Arias, MD, Lorena Mosso, MD

Implementation of Evidence-Based Guidelines for Thyroid Nodule Biopsy: A Model for Establishment of Practice Standards

AJR FOCUS ON:

Biopsy of Thyroid Nodules: Comparison of Three Sets of Guidelines

RadioGraphics

US Features of Thyroid Malignancy: Pearls and Pitfalls[1]

Benign and Malignant Thyroid Nodules: US Differentiation—Multicenter Retrospective Study[1]

Radiology

EnM ENDOCRINOLOGY AND METABOLISM

Review Article

Endocrinol Metab 2013;28:81-85
http://dx.doi.org/10.3803/EnM.2013.28.2.81
pISSN 2093-596X · eISSN 2093-5978

Indications for Fine Needle Aspiration in Thyroid Nodules

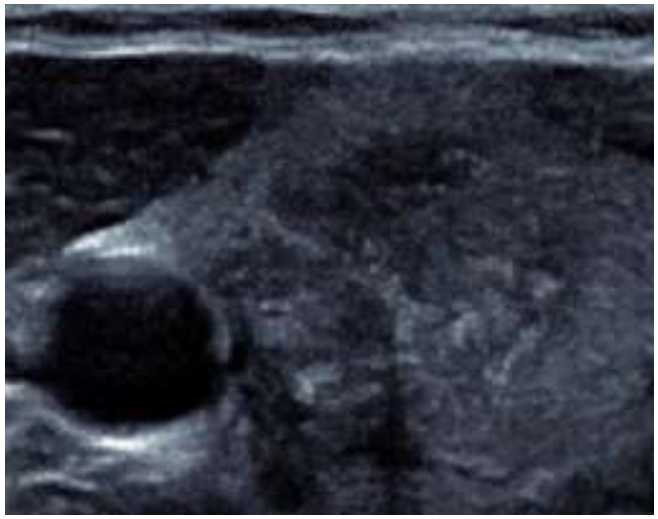
Jin Young Kwak

RadioGraphics

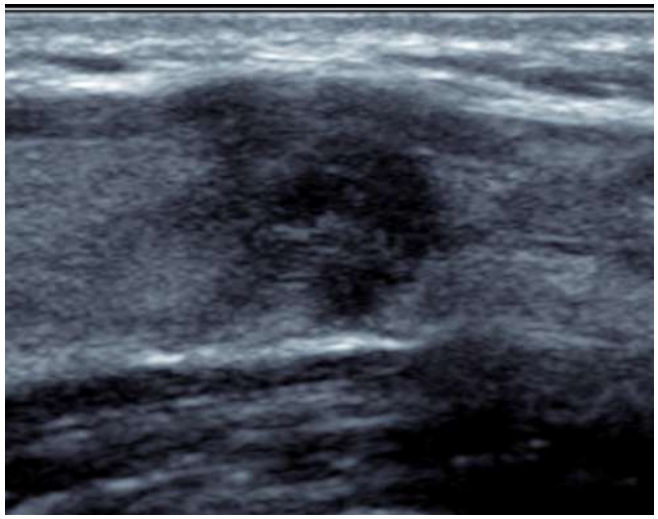
US-guided Fine-Needle Aspiration of Thyroid Nodules: Indications, Techniques, Results[1]

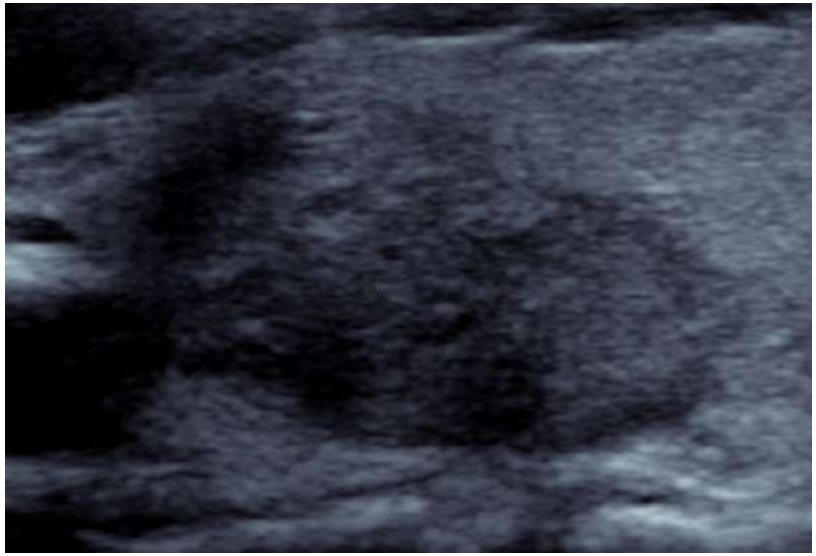
How most people feel about thyroid nodules….

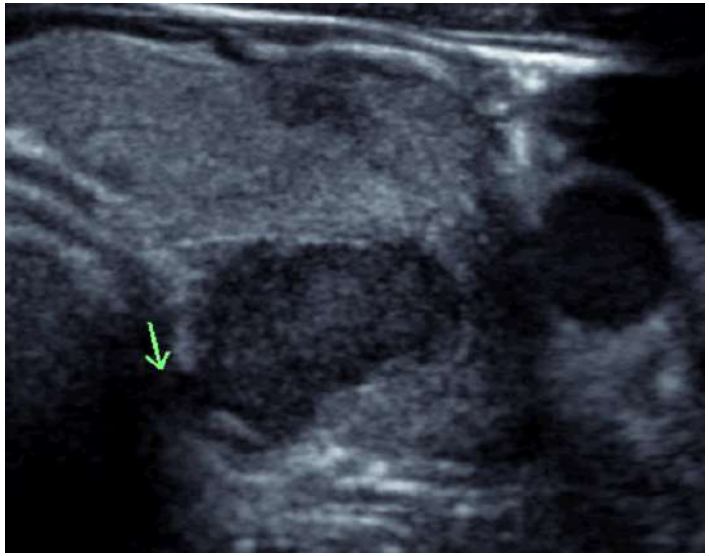
MARGINS



- Ill defined
  - 53-89% sensitivity
- Irregular, spiculated
  - 92% spec, 81% PPV
- Extrathyroid breach





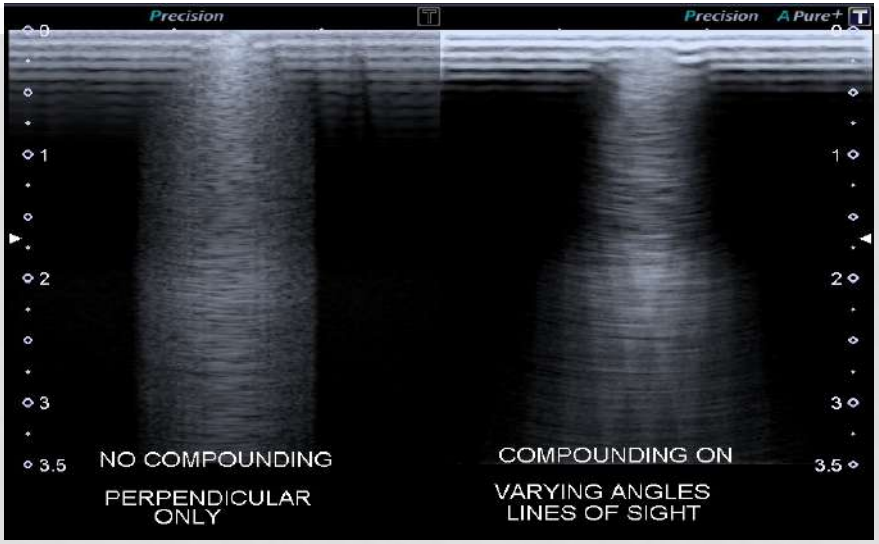


MARGINS*

**Worst Agreement*

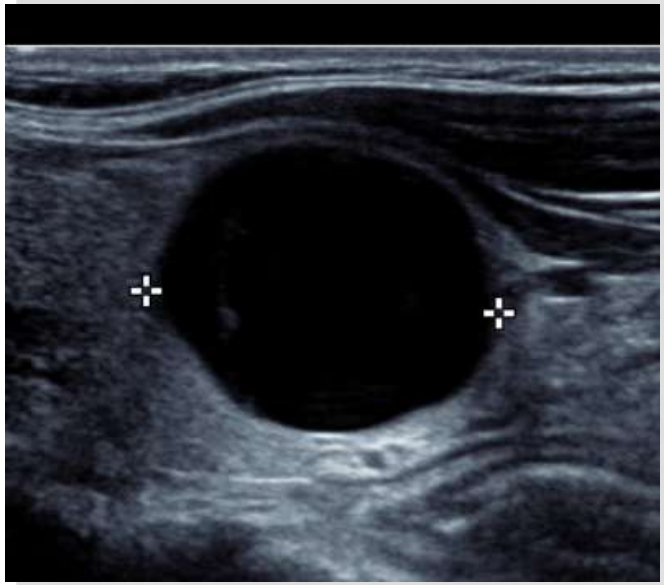
Technical point

- Higher frequencies
- Wider bandwidths
- Spatial compounding



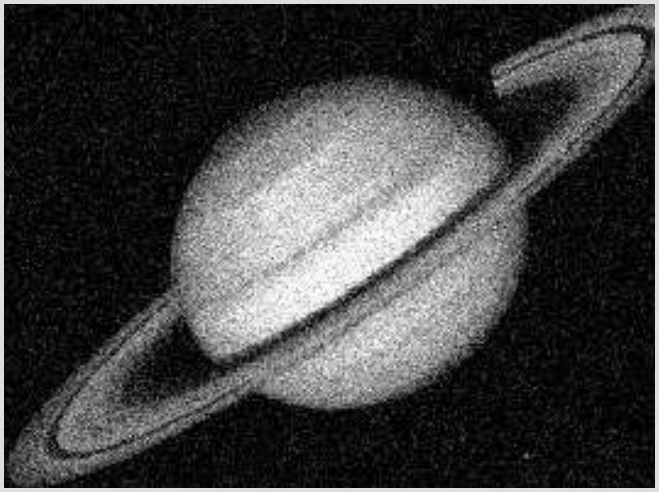
SOLID vs CYSTIC*

**Best Agreement*



- Purely cystic
  - ~100% NPV
- Spongiform
  - 99.7% NPV

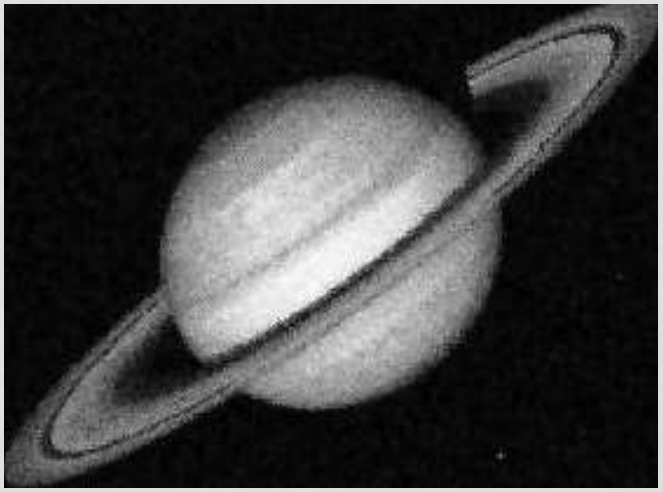
SOLID vs CYSTIC

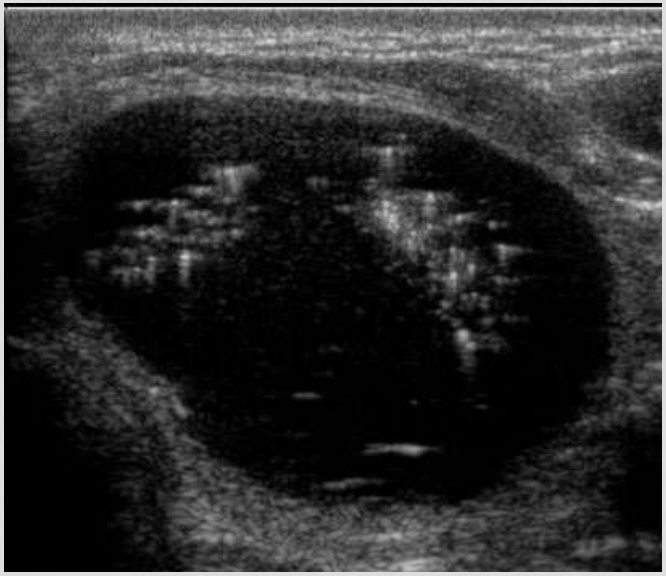


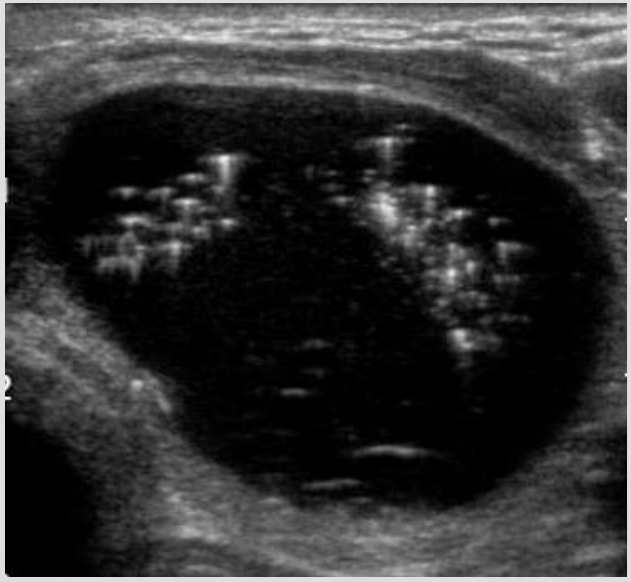
Technical point

- Signal processing

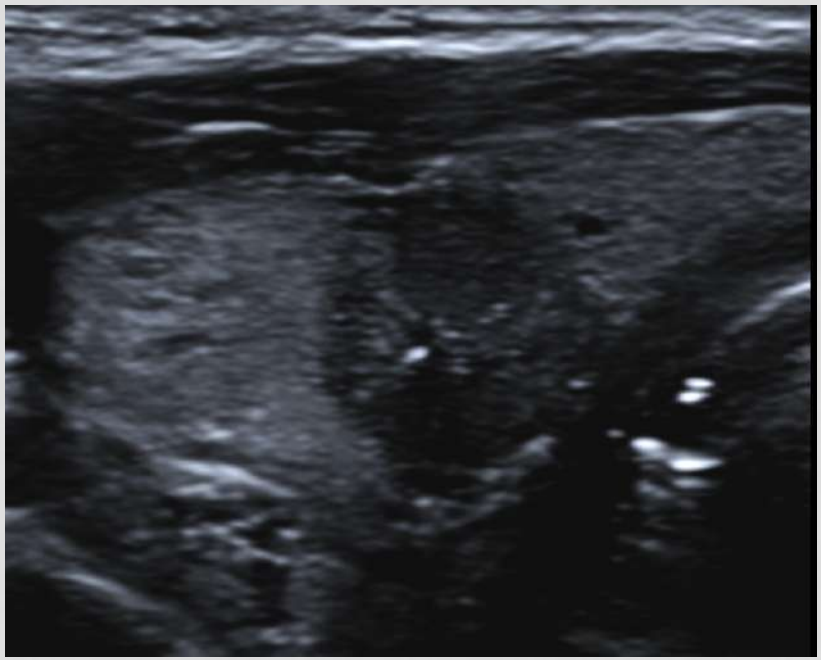
aka ‘speckle reduction’



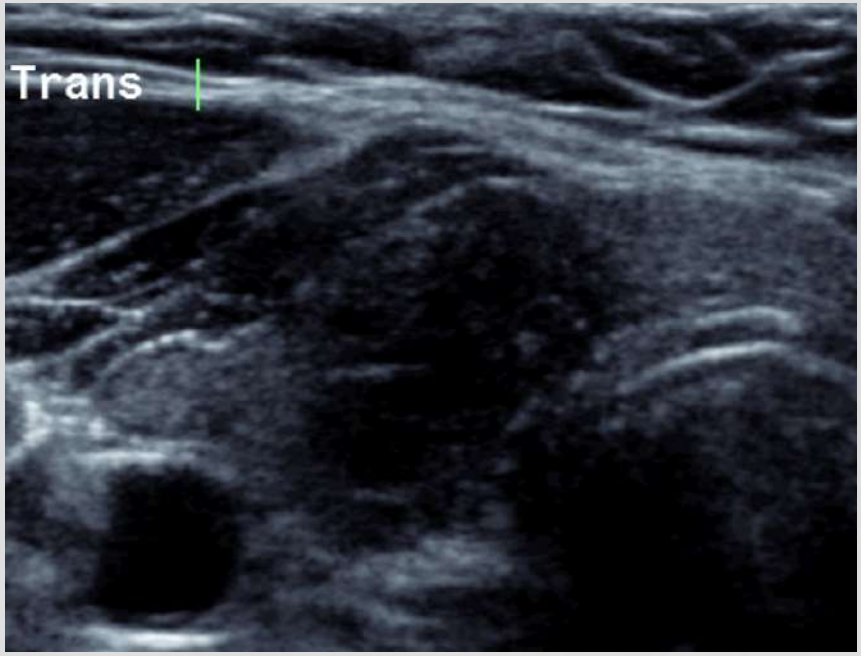




REFLECTIVITY



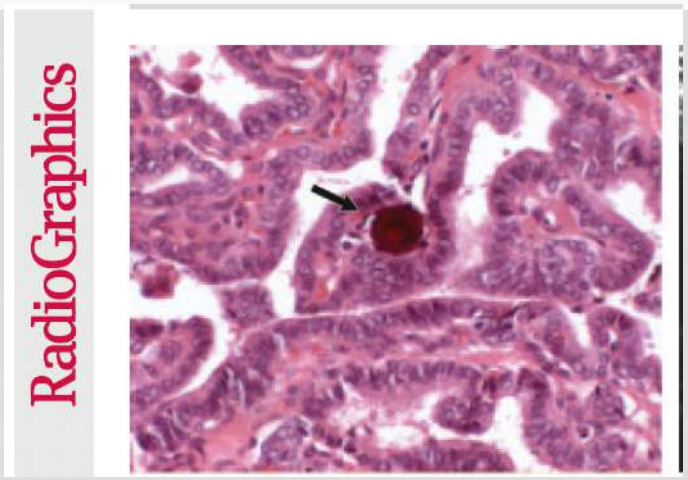
- Hypoechoic
  - 'less than normal thyroid'
  - 43% specificity, 86% sensitivity
- 'Marked hypoechoic'
  - 'less than strap muscle'
  - 92-94% specificity, 41% sensitivity



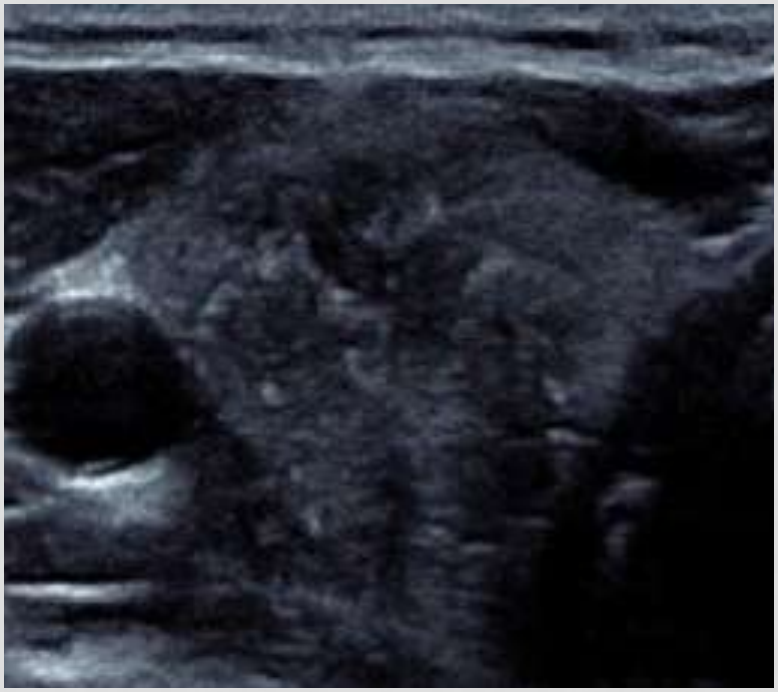
Technical point

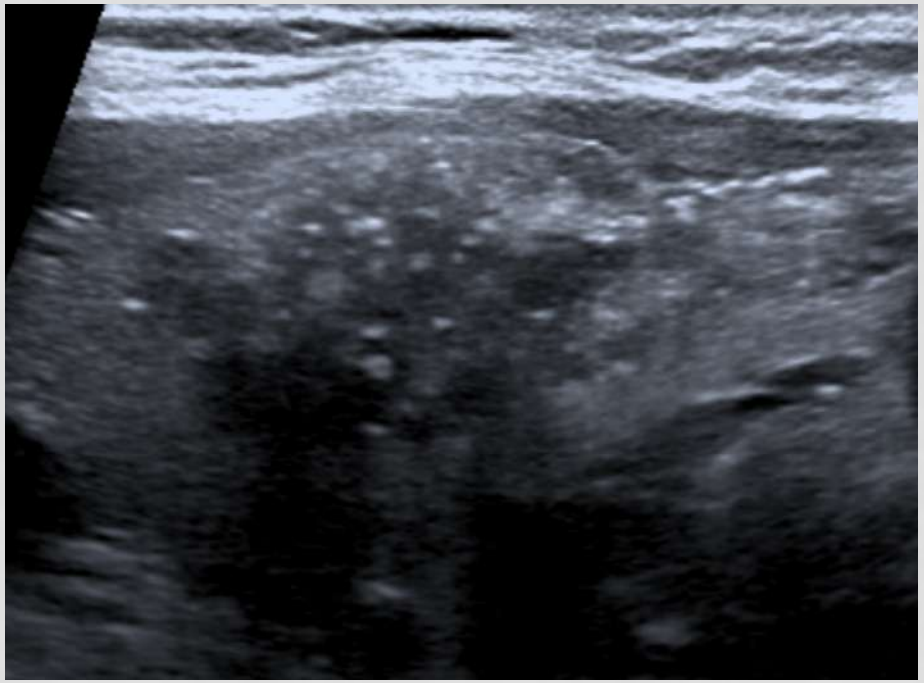
- Grey scale map & dynamic range are crucial
- Varies between users & US platforms

CALCIFICATION

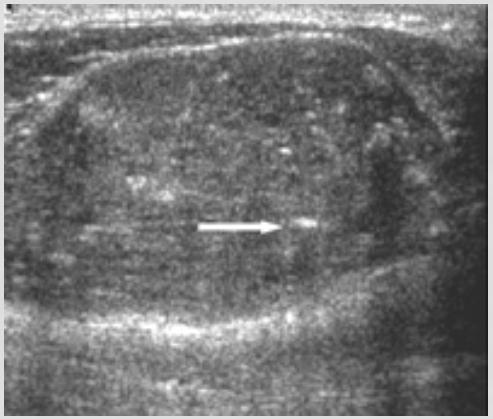


- Microcalcification
  - ≤ 2mm
  - 86-95% spec, OR 28.1



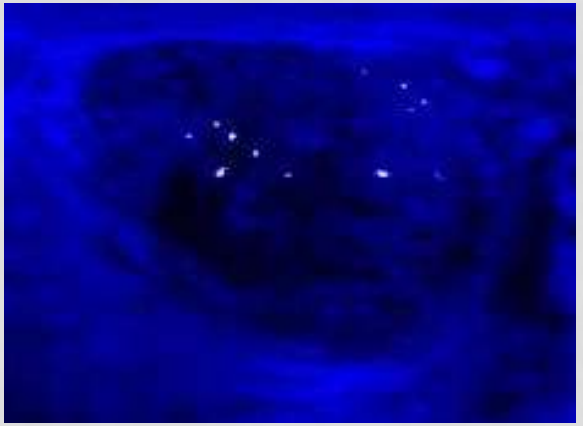


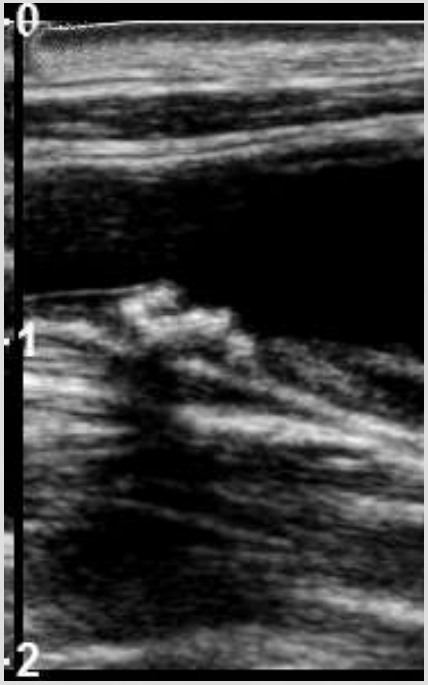
CALCIFICATION

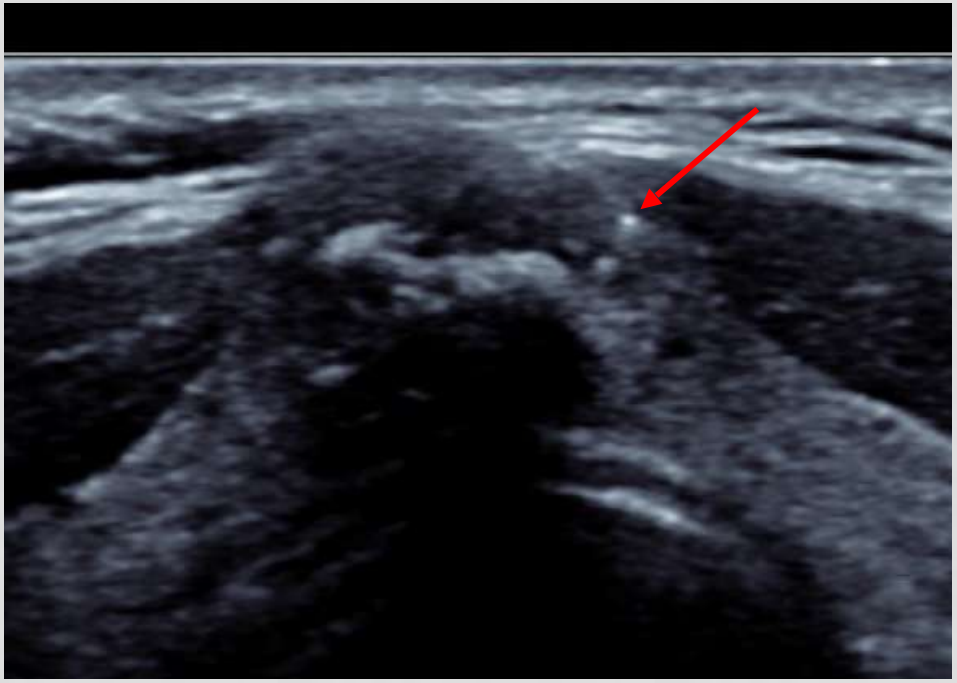


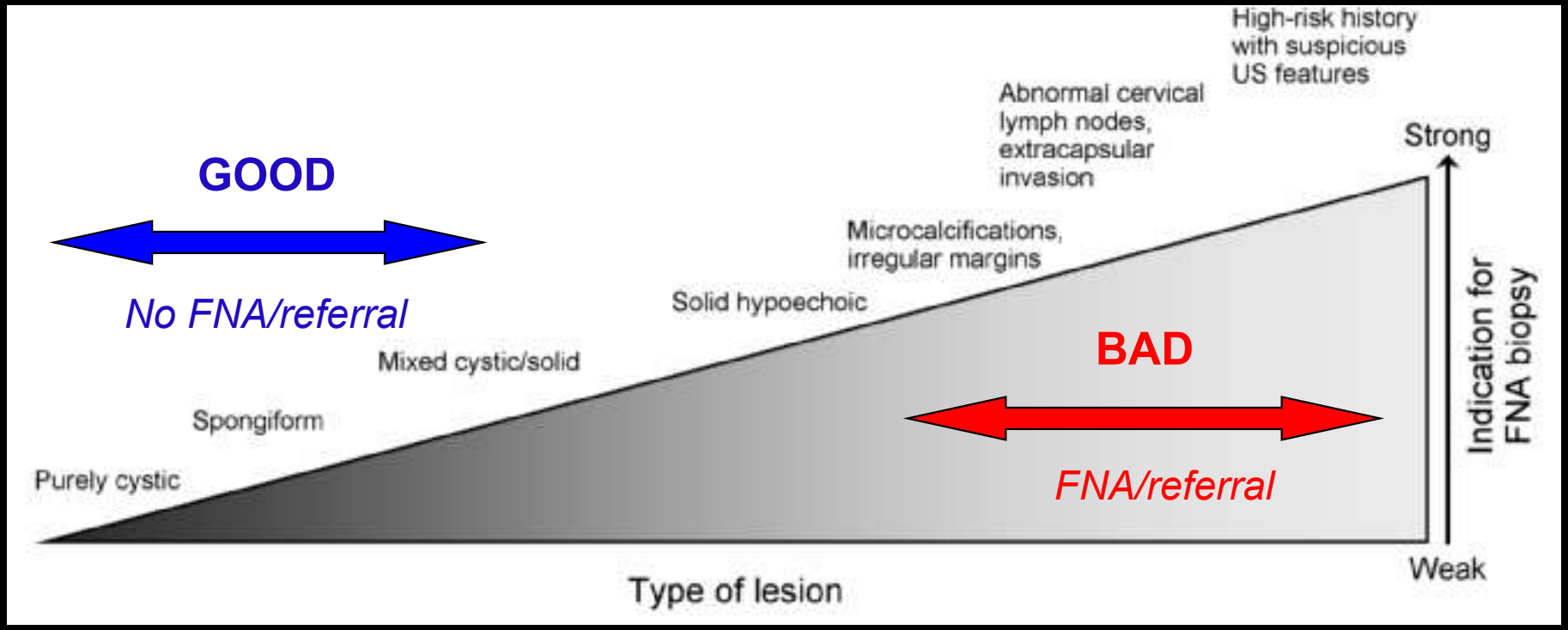
Technical point

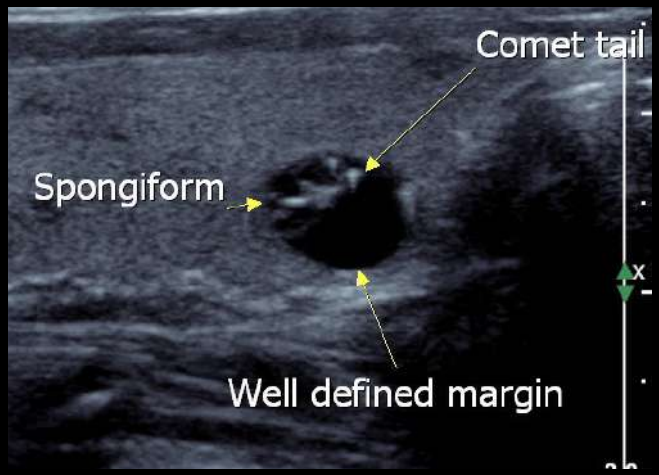
- Spatial Compounding
  - Less ‘acoustic shadow’
- Calcification detection

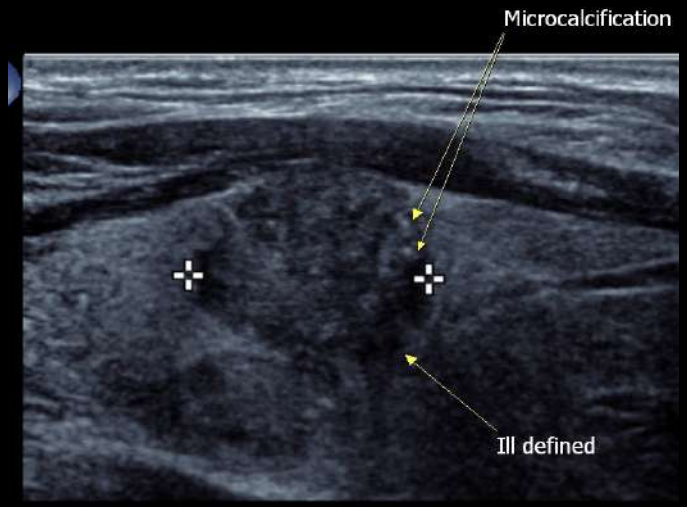




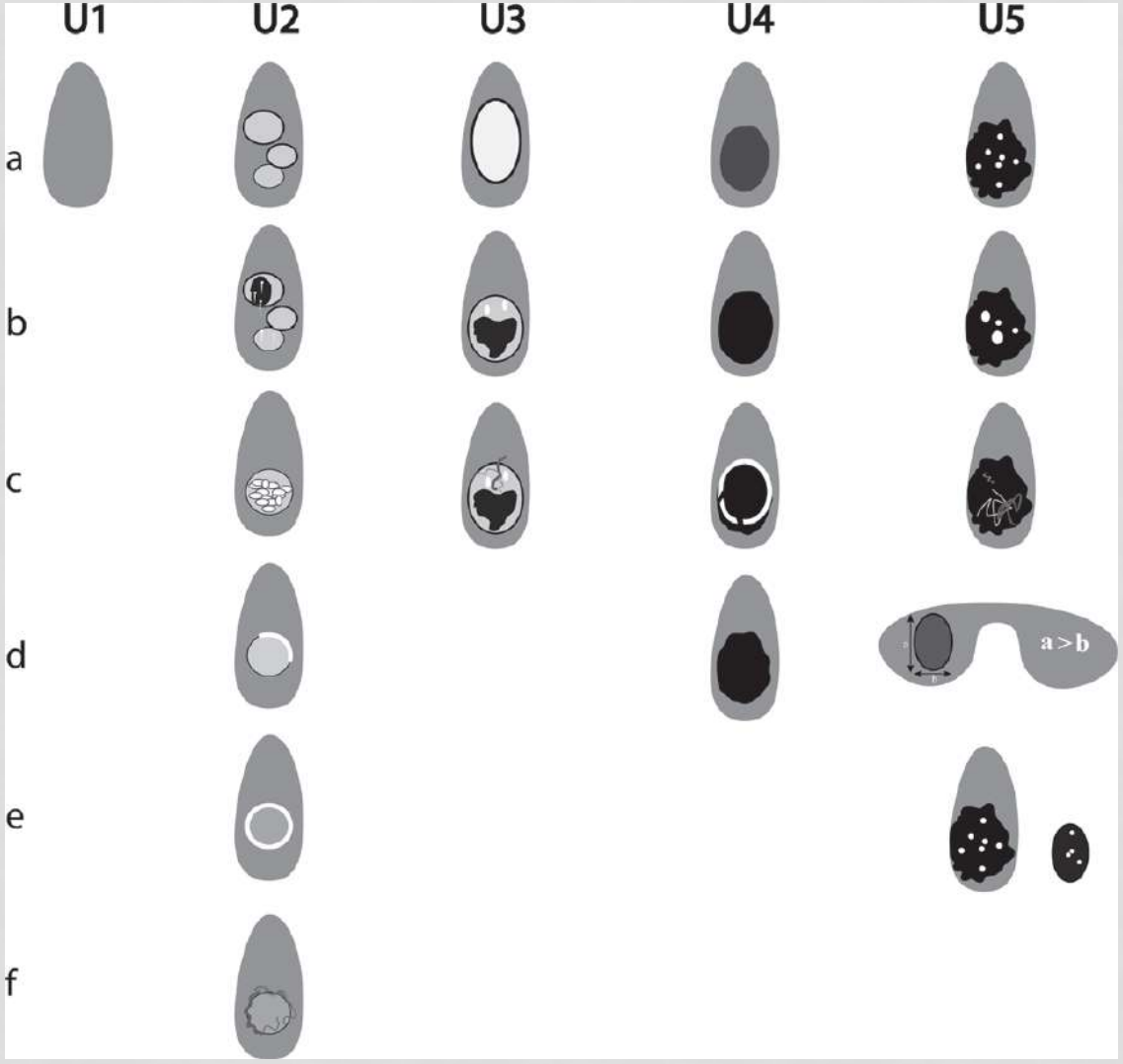



GOOD
No FNA/referral
Purely cystic
Spongiform
Mixed cystic/solid
Solid hypoechoic
Microcalcifications, irregular margins
Abnormal cervical lymph nodes, extracapsular invasion
High-risk history with suspicious US features
BAD
FNA/referral
Strong
Weak
Indication for FNA biopsy
Type of lesion


Comet tail
Spongiform
Well defined margin

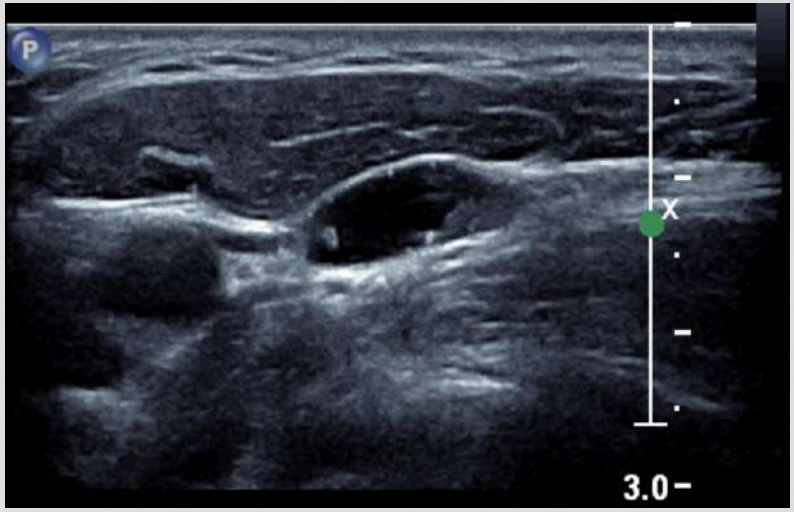

Microcalcification
Ill defined

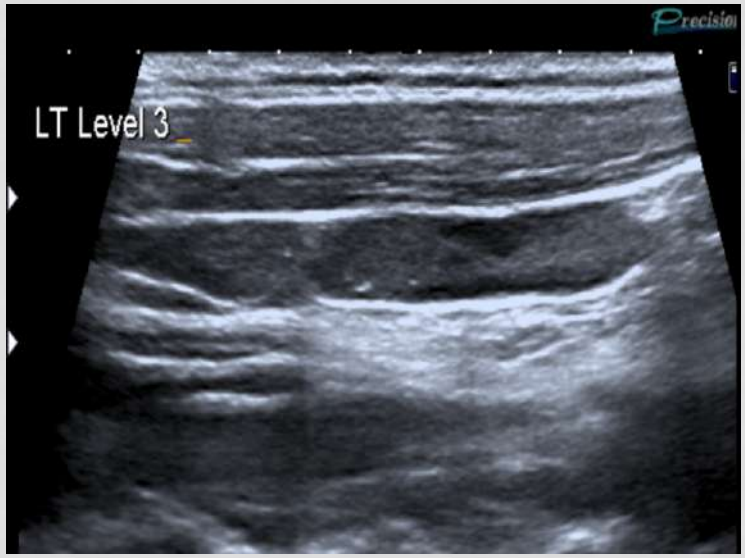
BTA 2014 NODULE CLASSIFICATION

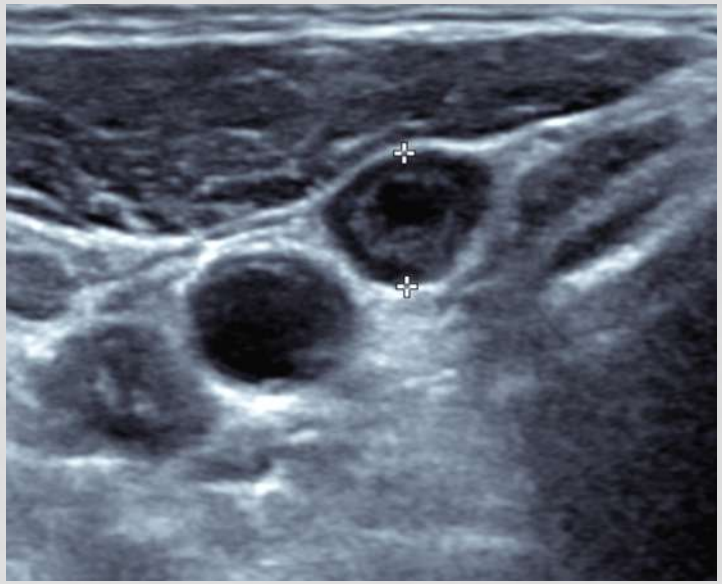


HIGH RESOLUTION US:

Detailed anatomical characterisation

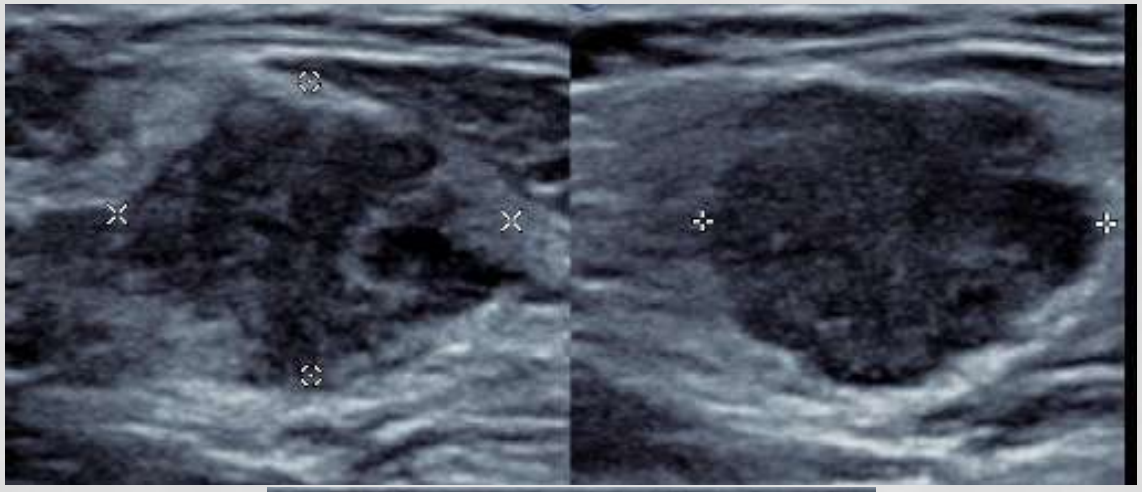


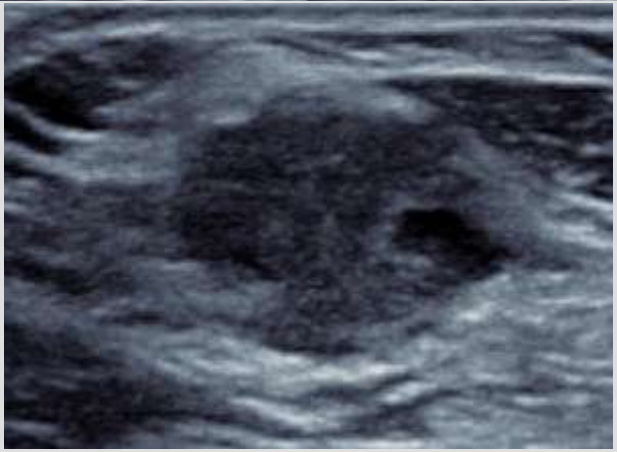


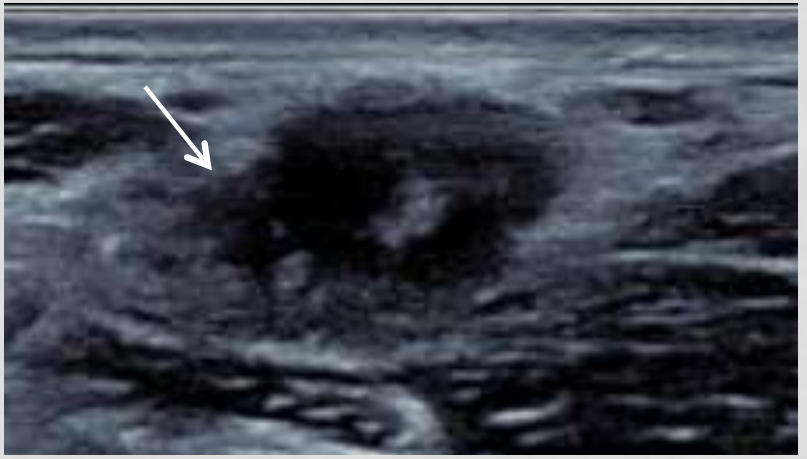


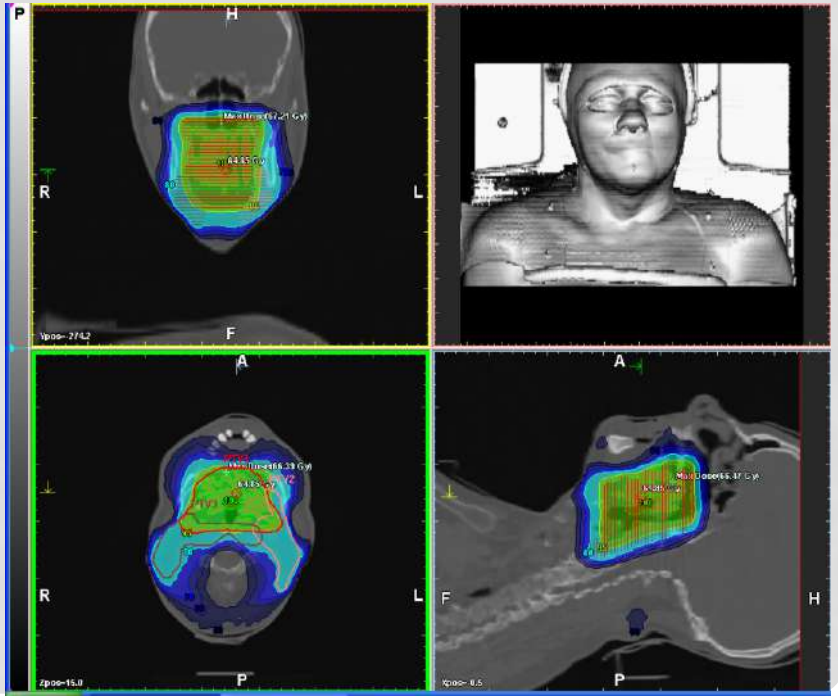
HIGH RESOLUTION US:

Seeing more – changing management





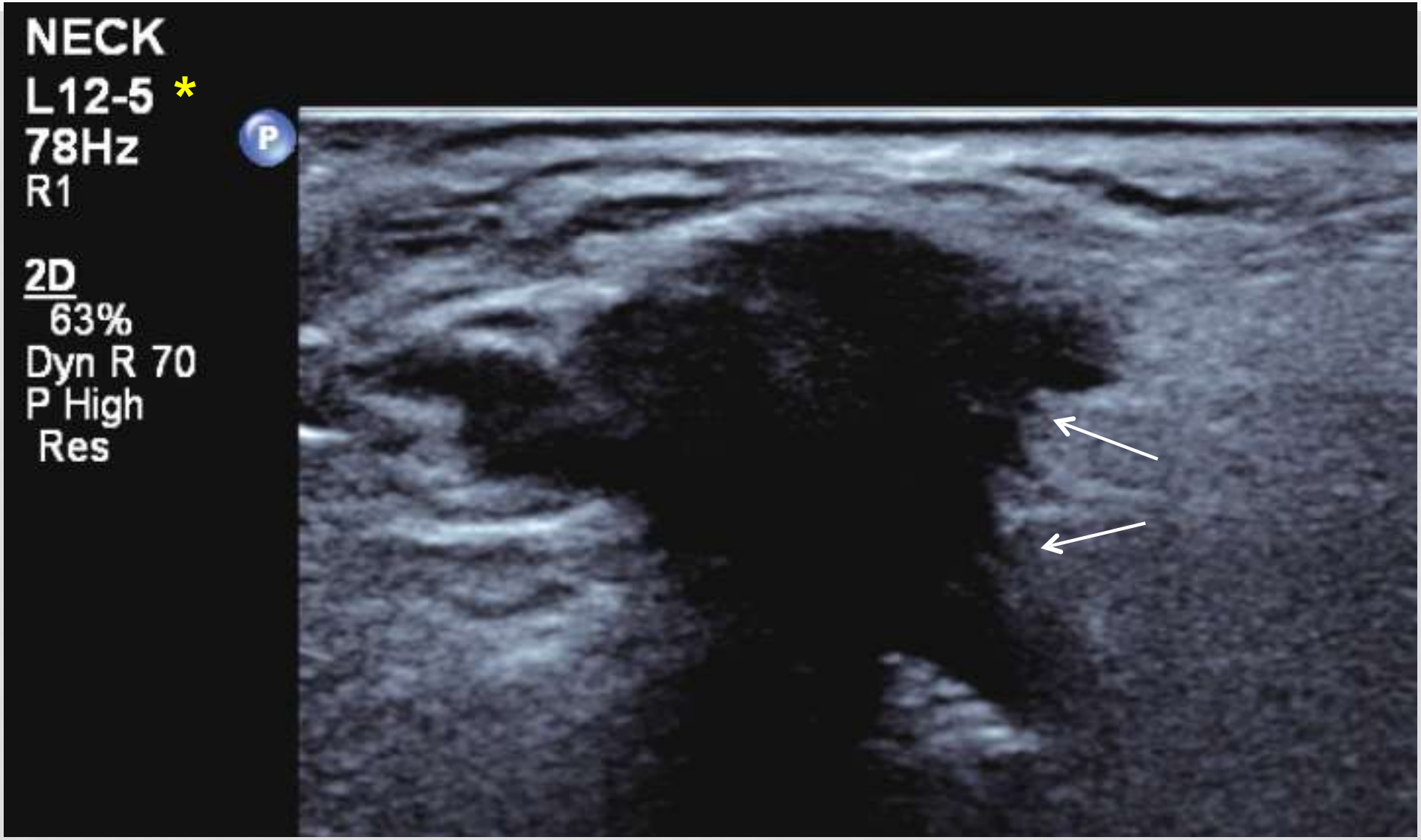




Richards PS, Peacock TE. The role of US in the detection of cervical lymph node metastases in clinical N0 squamous cell carcinoma of the head & neck. *Cancer Imaging* 2007;7:167-178

HIGH RESOLUTION US:

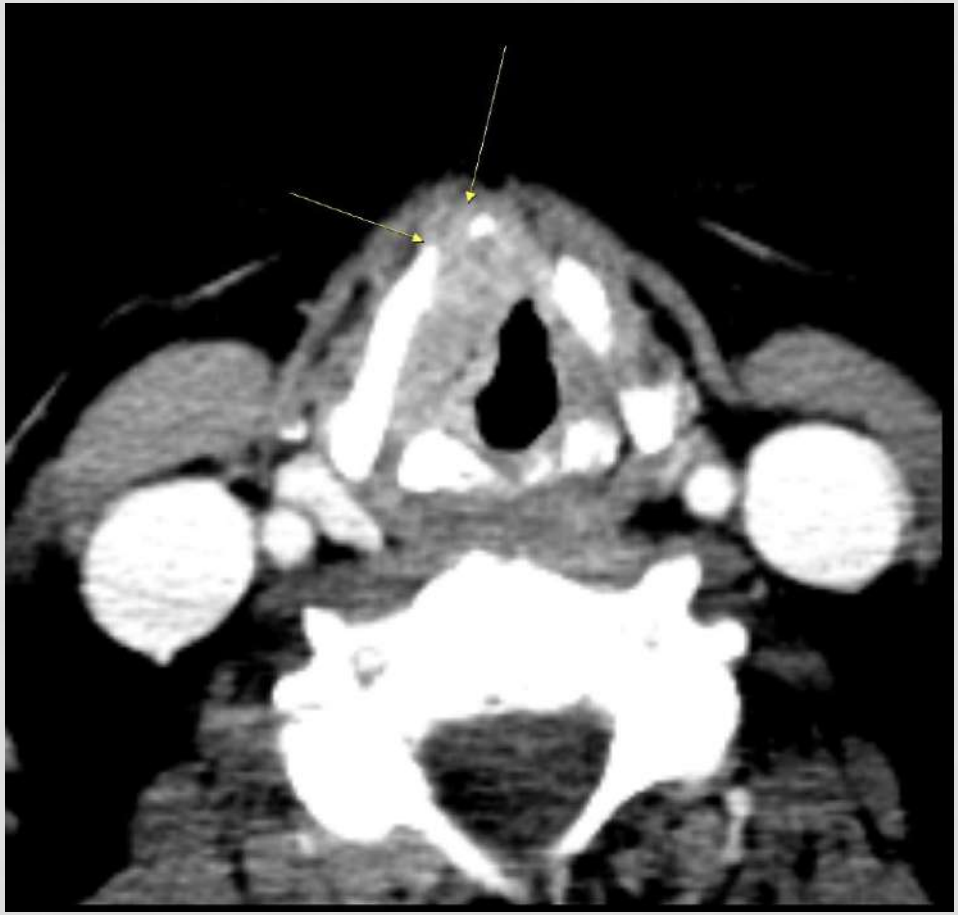
Seeing more – changing management

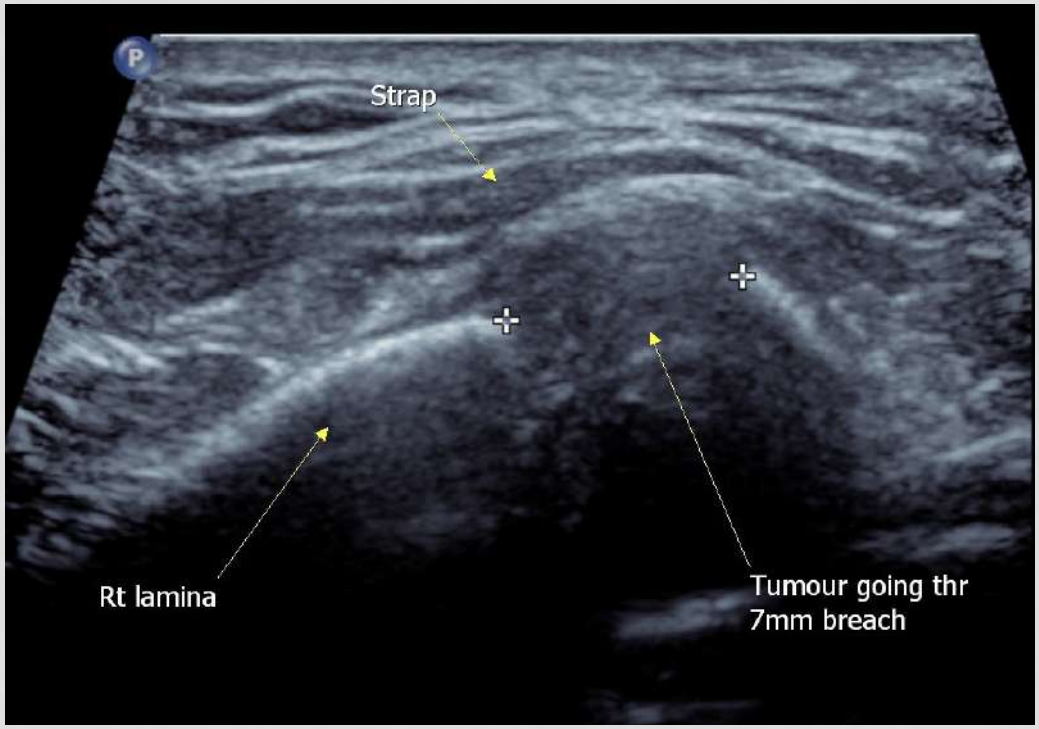


HIGH RESOLUTION US:

Troubleshooting in the larynx

MDT Question: Is this right laryngeal tumour just into thyroid cartilage **(T3)** or does it show extralaryngeal spread **(T4)?**



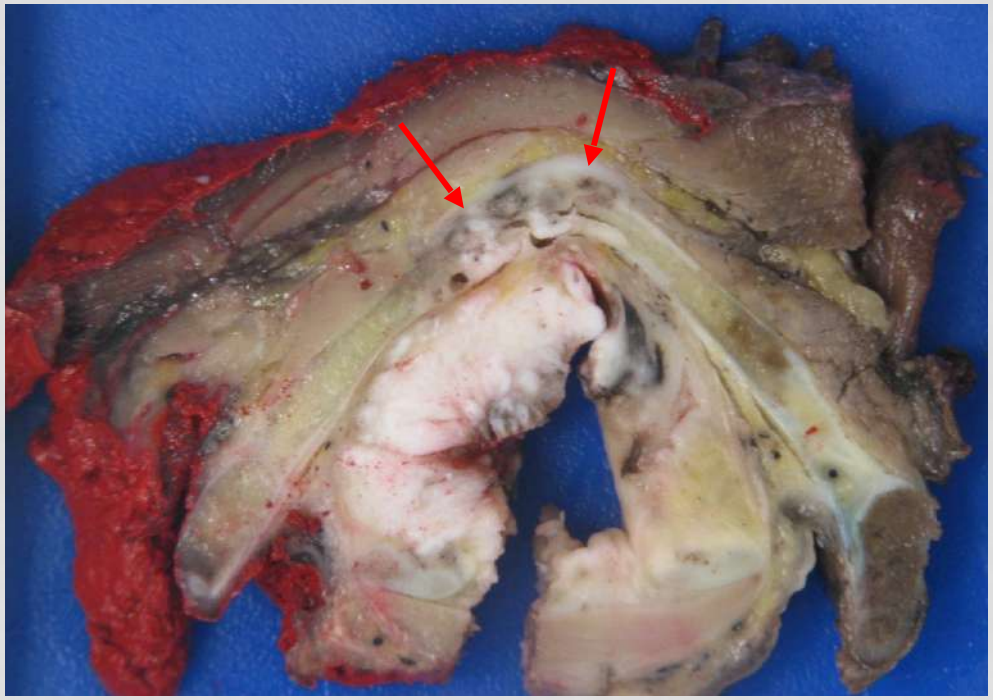


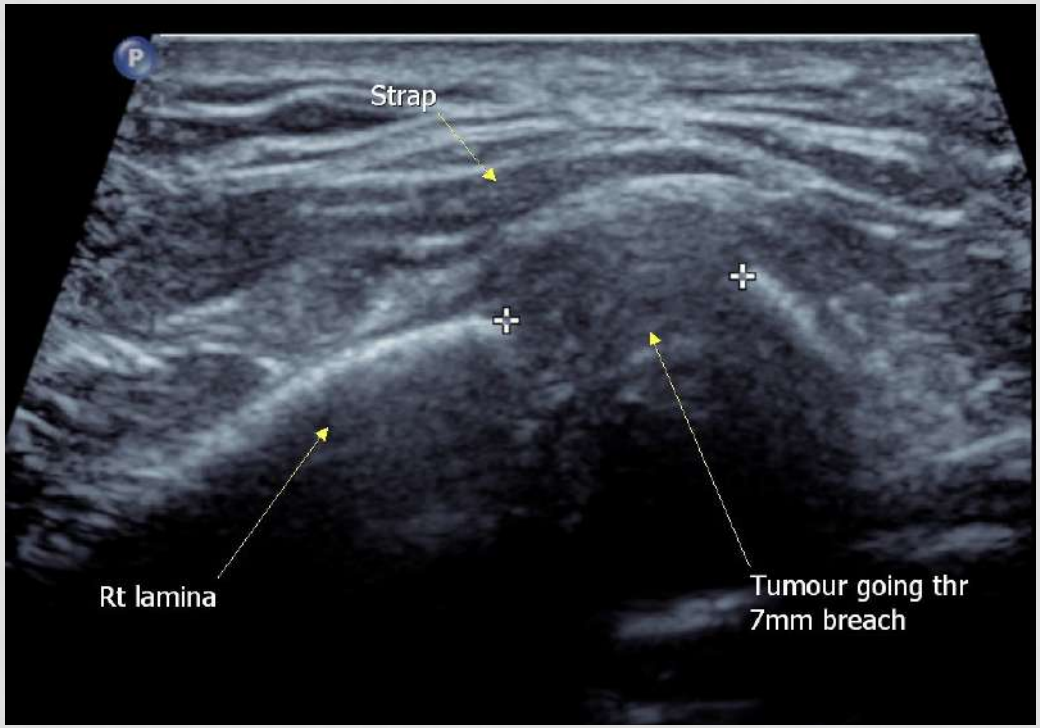
HIGH RESOLUTION US:

Troubleshooting in the larynx

Response to MDT: I am sure its T4

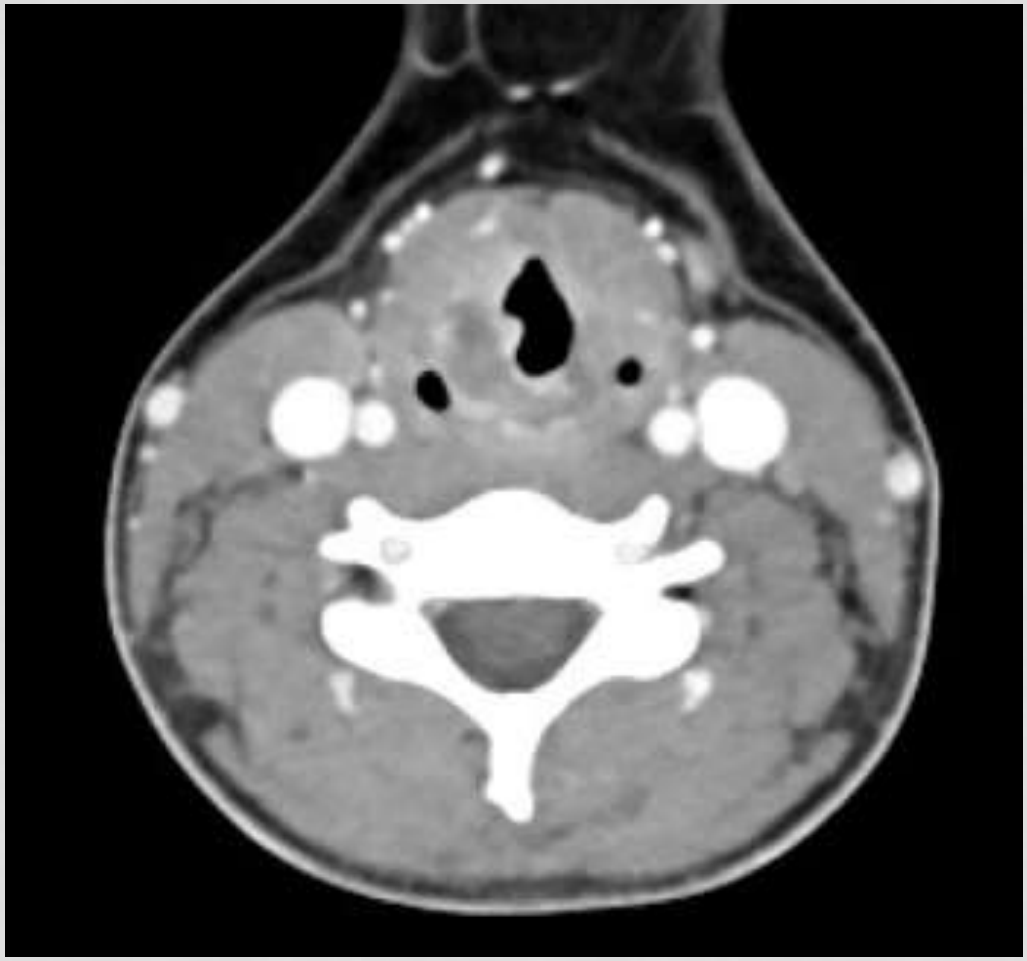
MDT: OK, laryngectomy it is then..

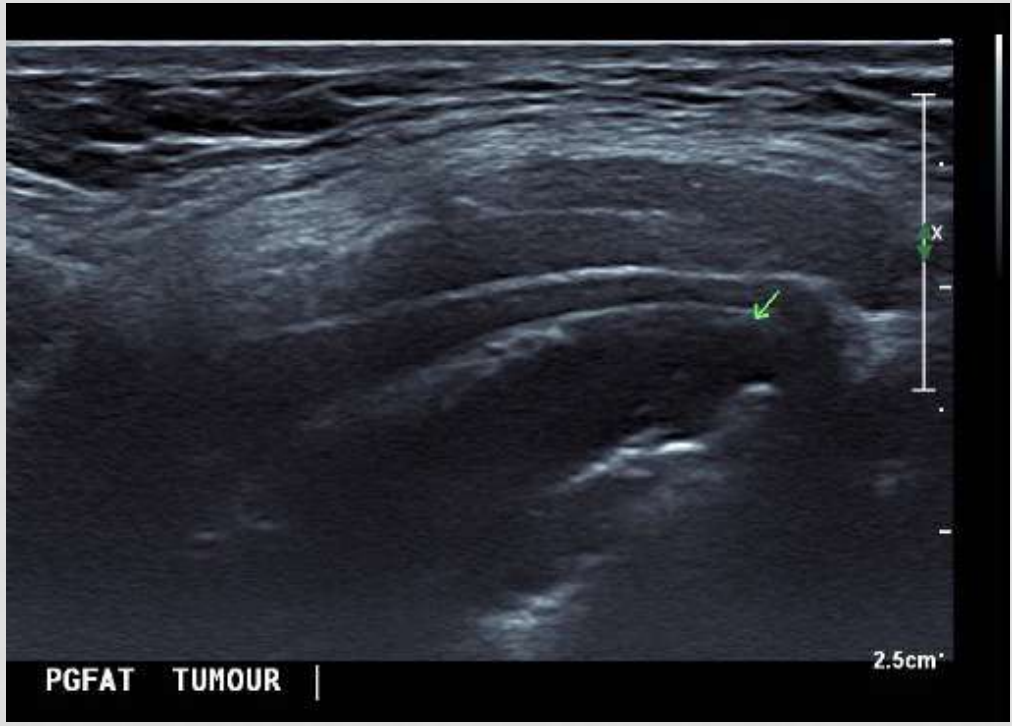




HIGH RESOLUTION US:

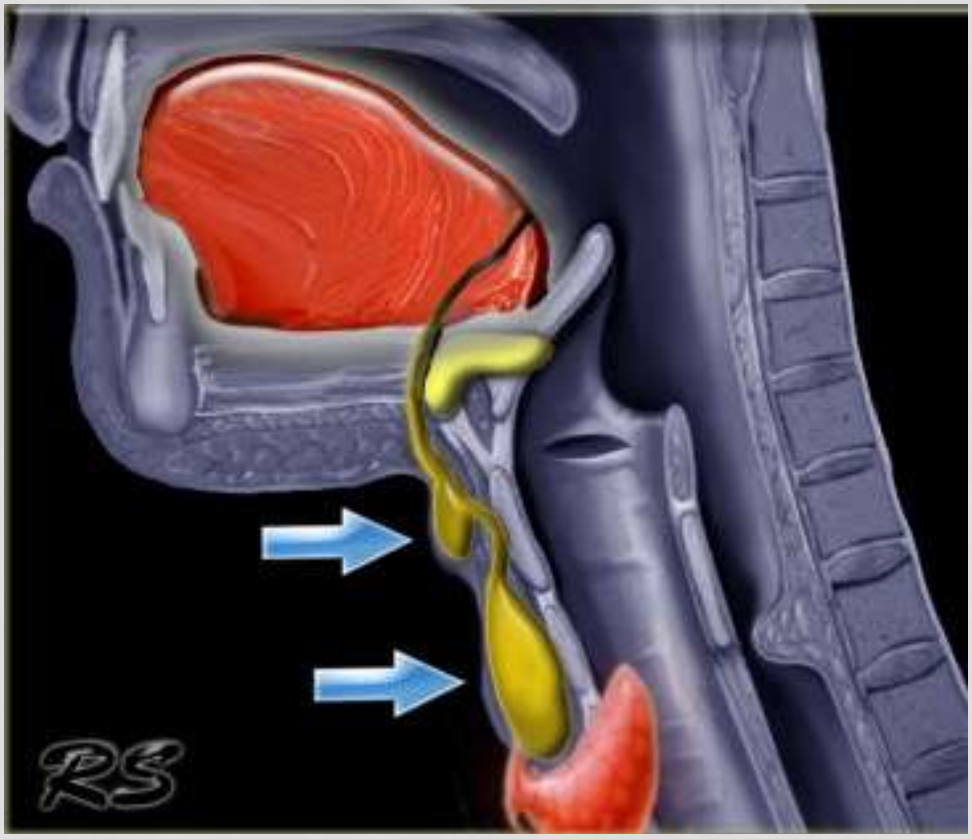
Troubleshooting in the larynx





HIGH RESOLUTION US:

Paediatrics – midline neck swellings

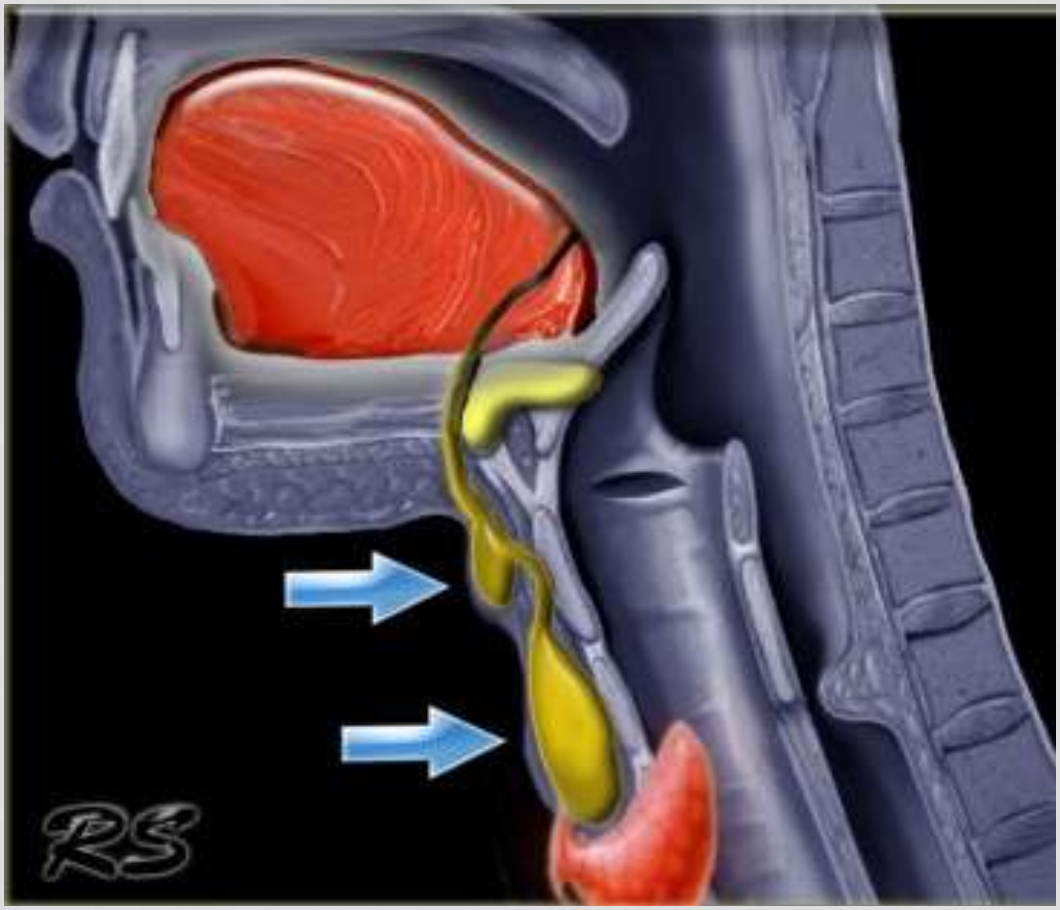


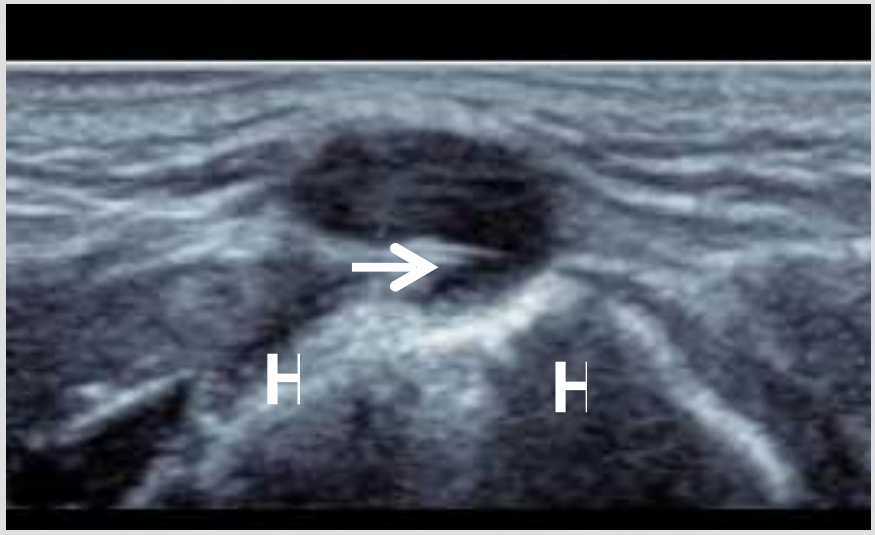
HIGH RESOLUTION US:

Paediatrics – midline neck swellings

HIGH RESOLUTION US:

Paediatrics – midline neck swellings

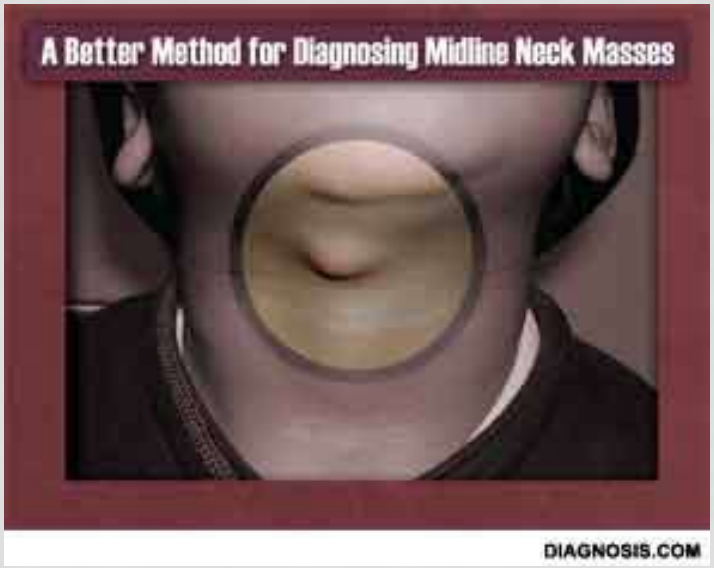


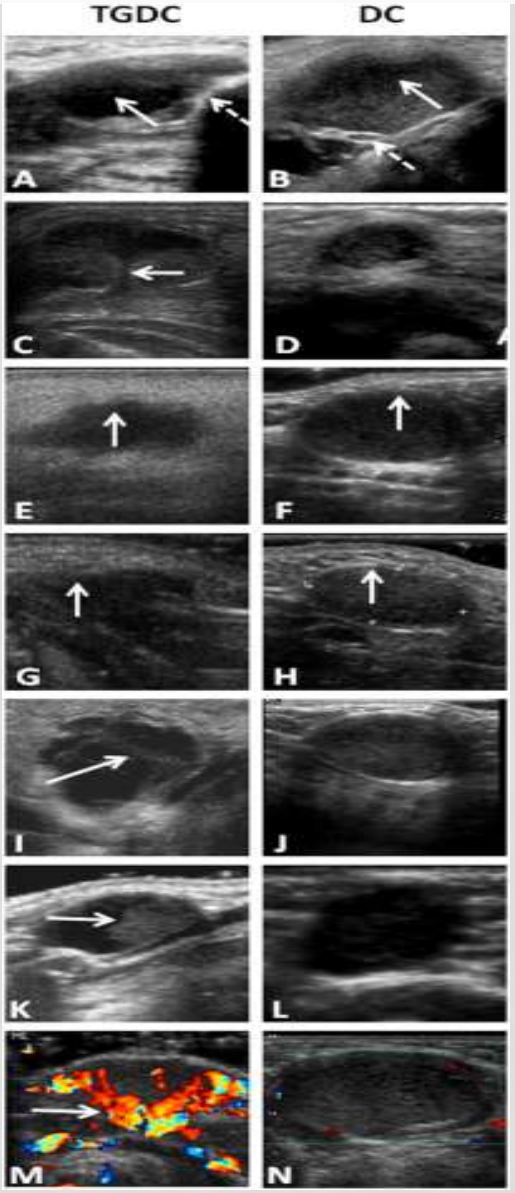


HIGH RESOLUTION US:

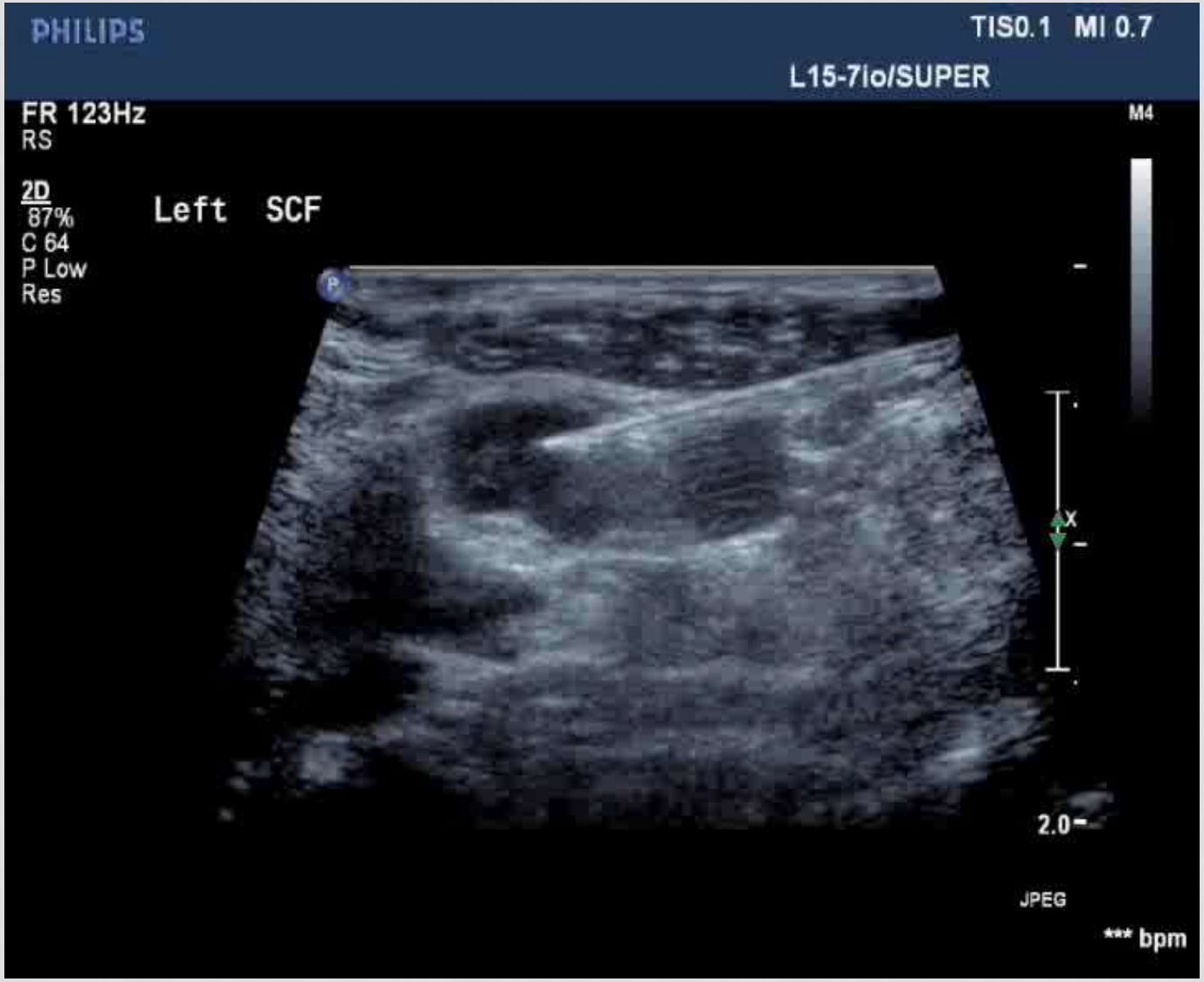
Paediatrics – midline neck swellings

- 2012 - Hugh et al.
  - US superior to CT & MRI
  - + Likelihood Ratio 3.8
- 2015 – Oyewumi et al.
  - Presence of tract = 100% PPV



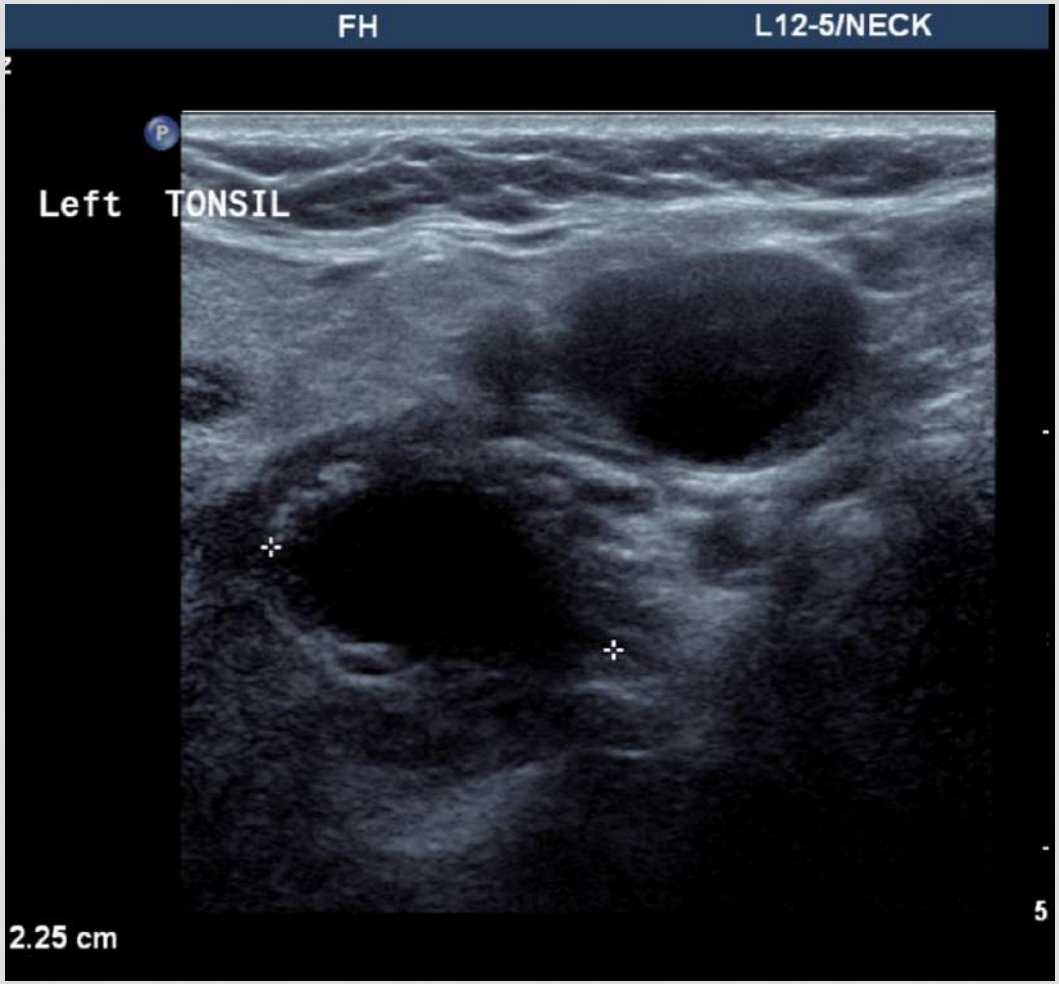


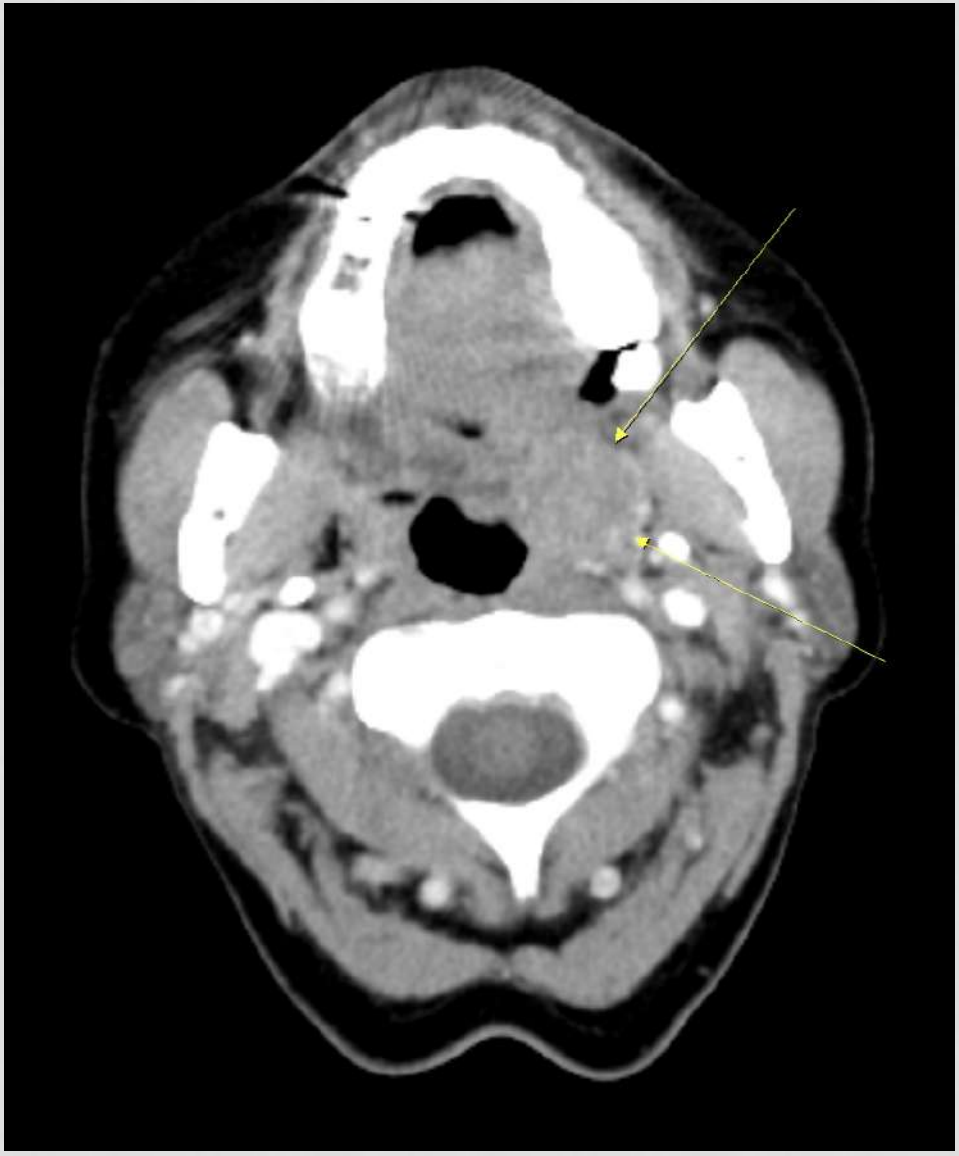
HIGH RESOLUTION US:
Near field guidance



HIGH RESOLUTION US:

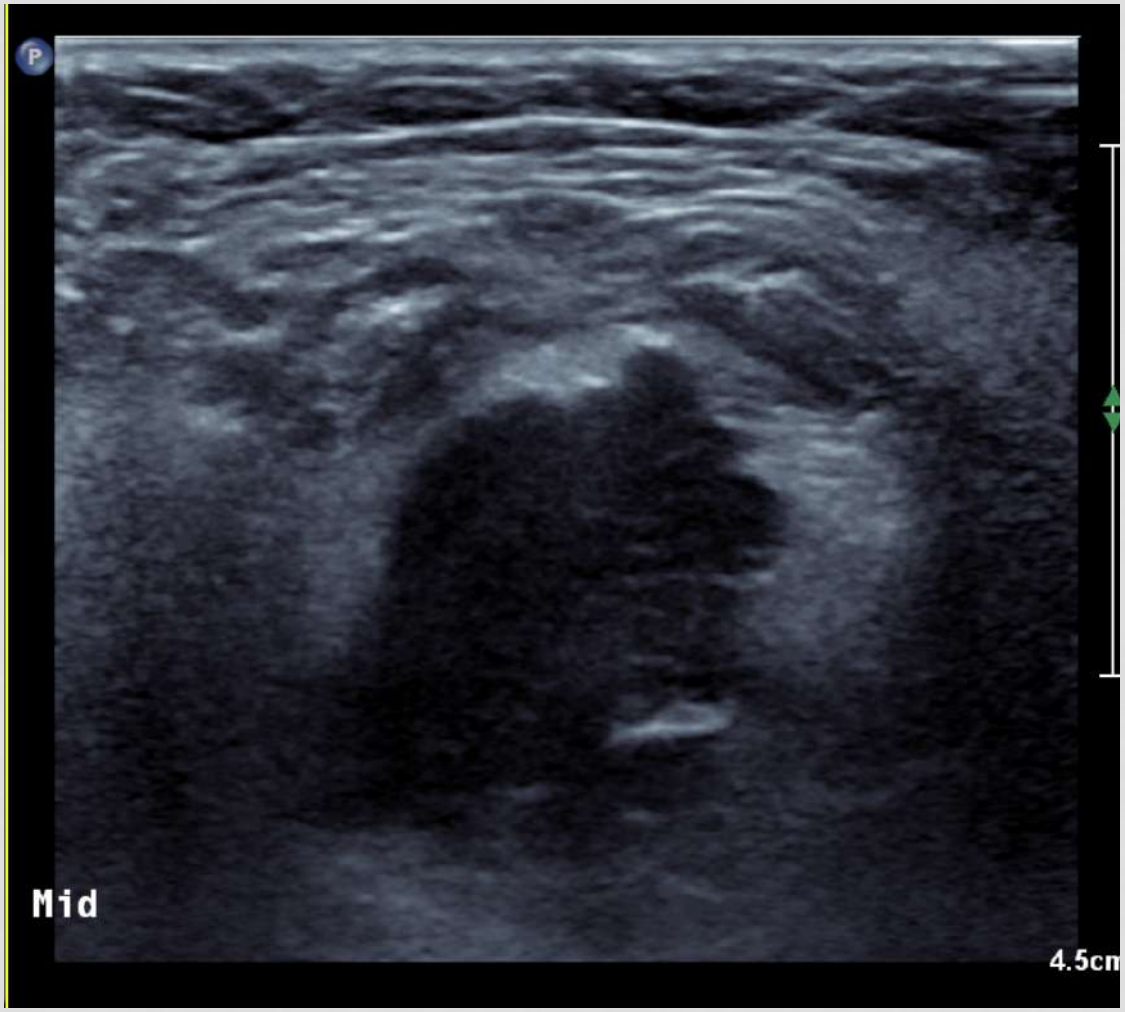
Improved penetration

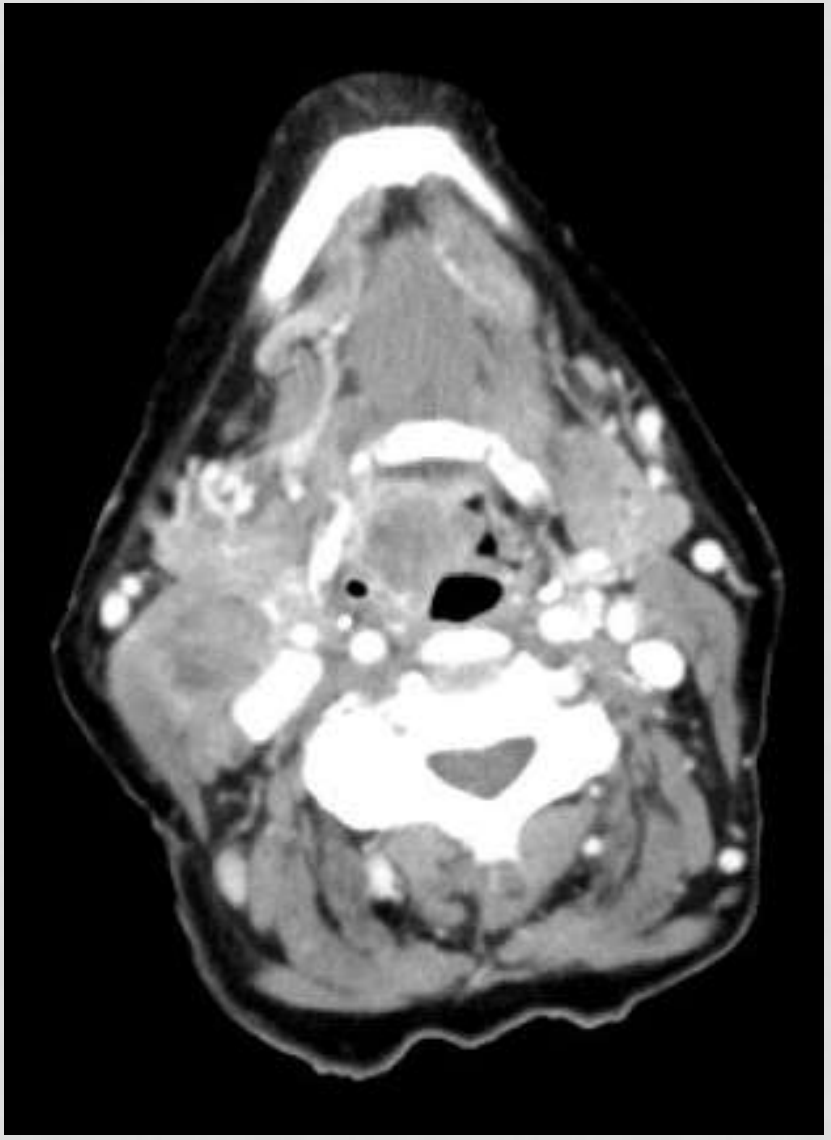




HIGH RESOLUTION US:

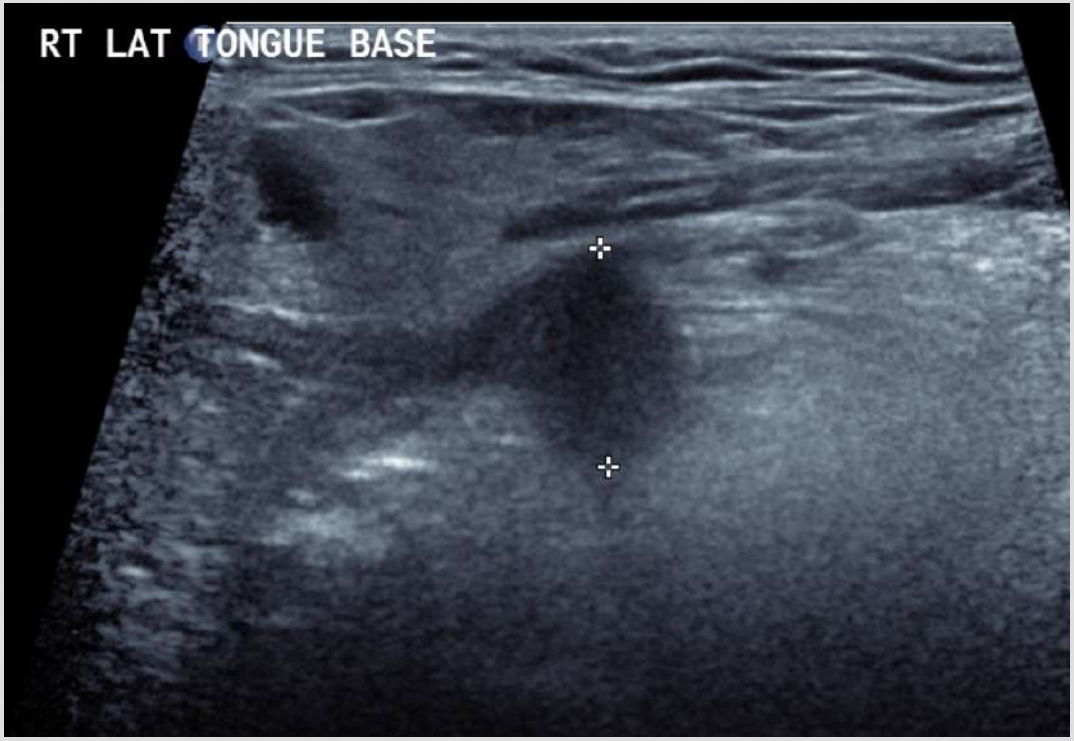
Improved penetration

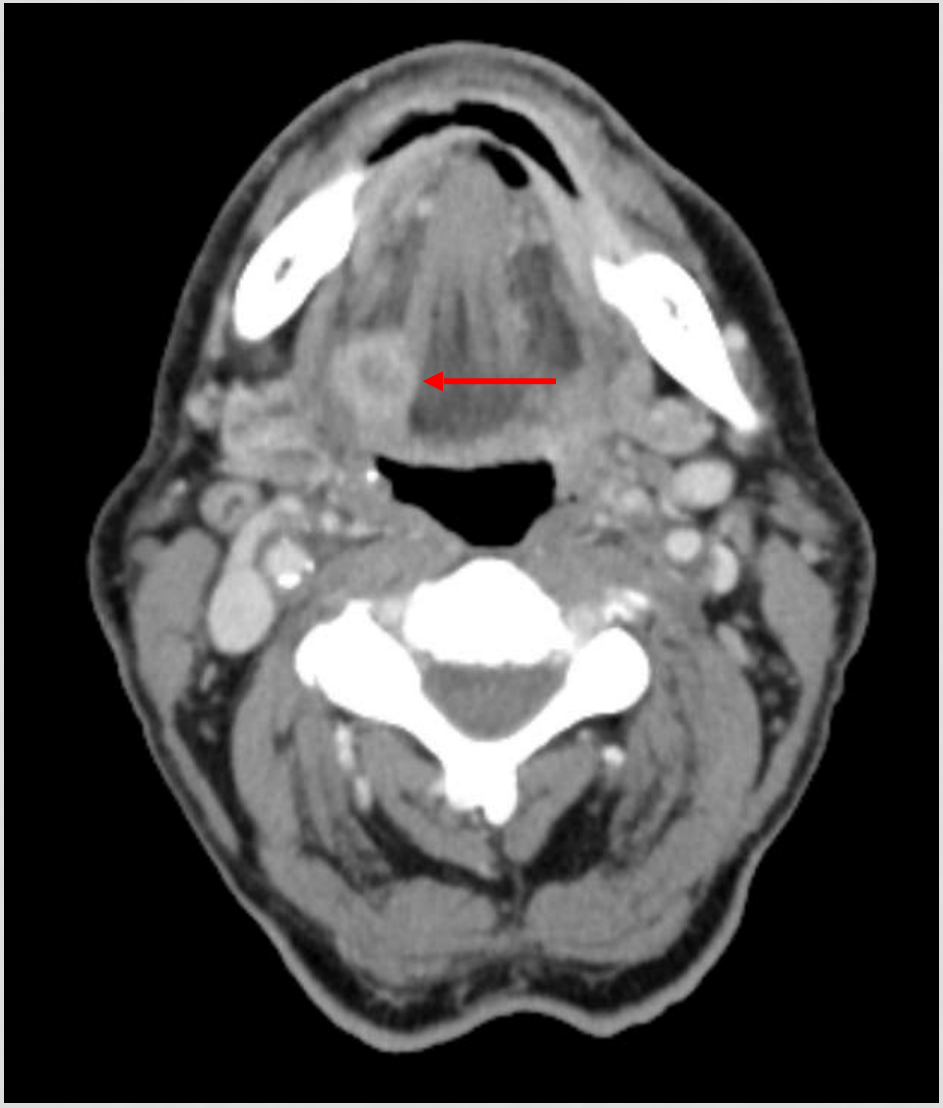




HIGH RESOLUTION US:

Improved penetration

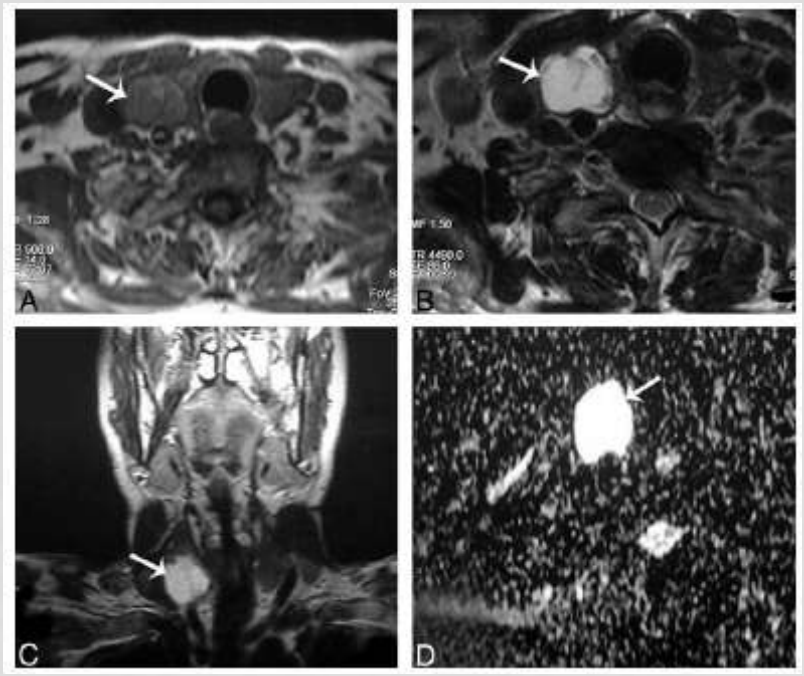


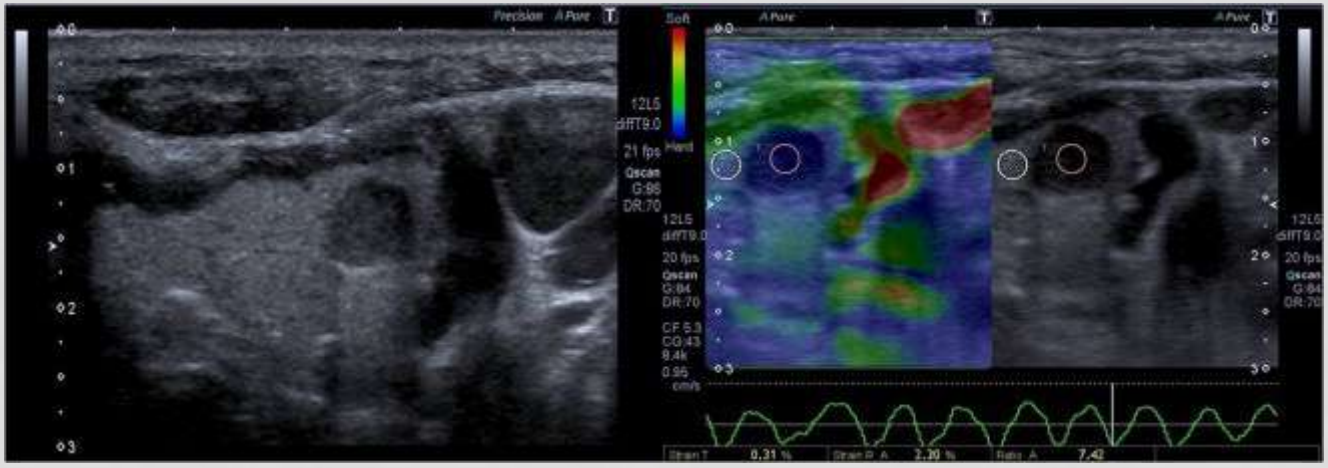


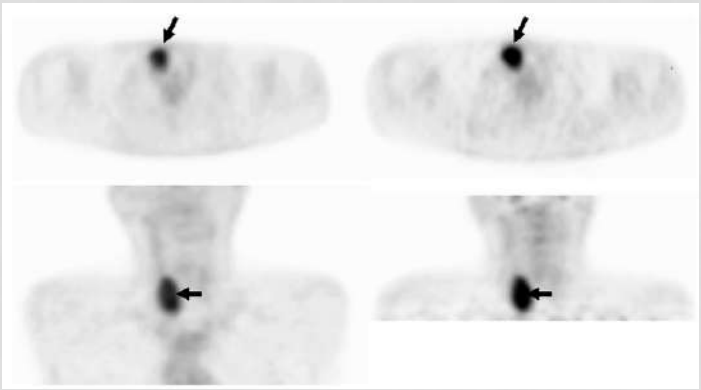
ADVANCES IN NECK ULTRASOUND

Lesion characterisation (microstructure, function)

- US elastography
- CEUS
- DWI & DCE MRI
- PET-CT
- Dual energy CT



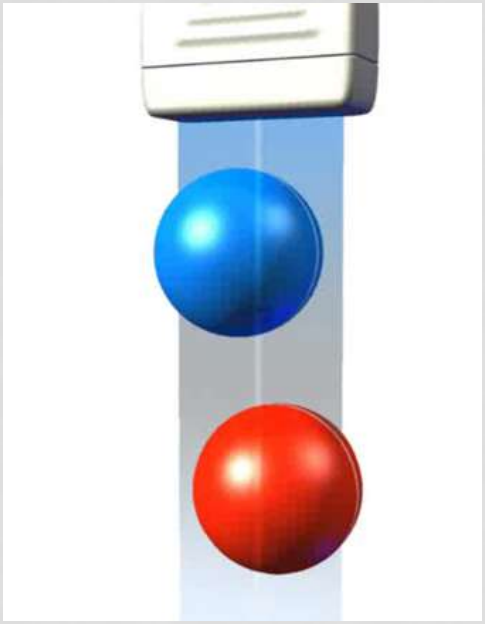


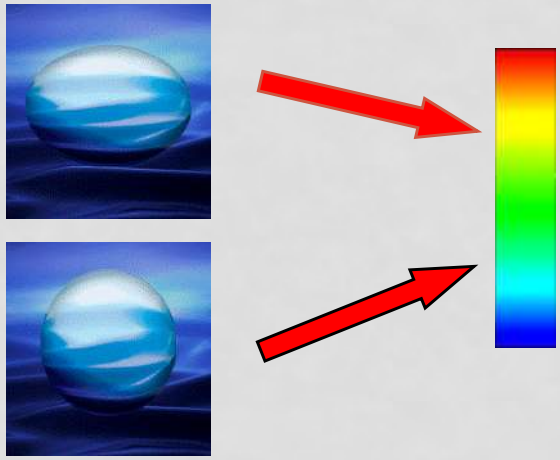


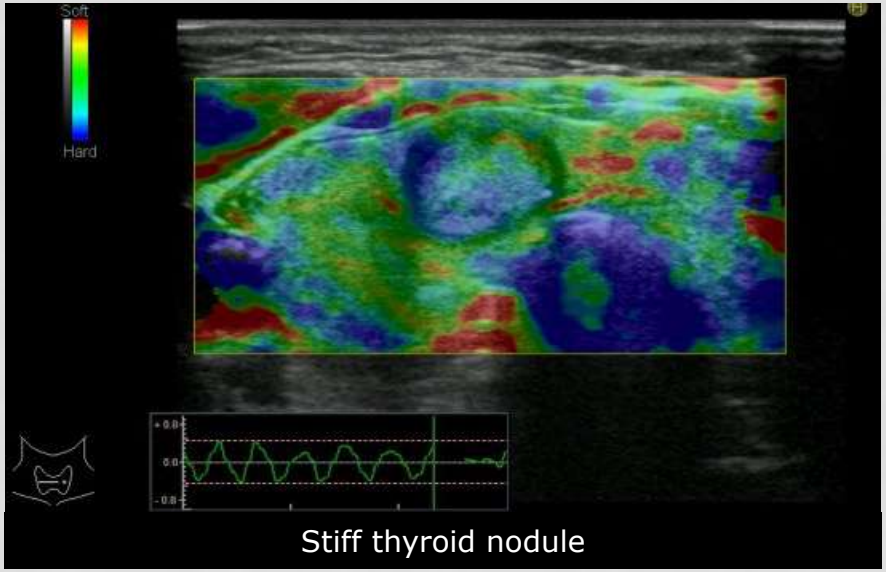
STRAIN ELASTOGRAPHY - *TECHNIQUE*

Applied force displaces tissue

- Mechanical compression or arterial pulsation







Examples: HiRTE (Hitachi), Q elasto (Toshiba)

STRAIN ELASTOGRAPHY - *ASSESS*

Clinical Endocrinology (2013)

THYROID

Does elastography reduce the need for thyroid FNAs?

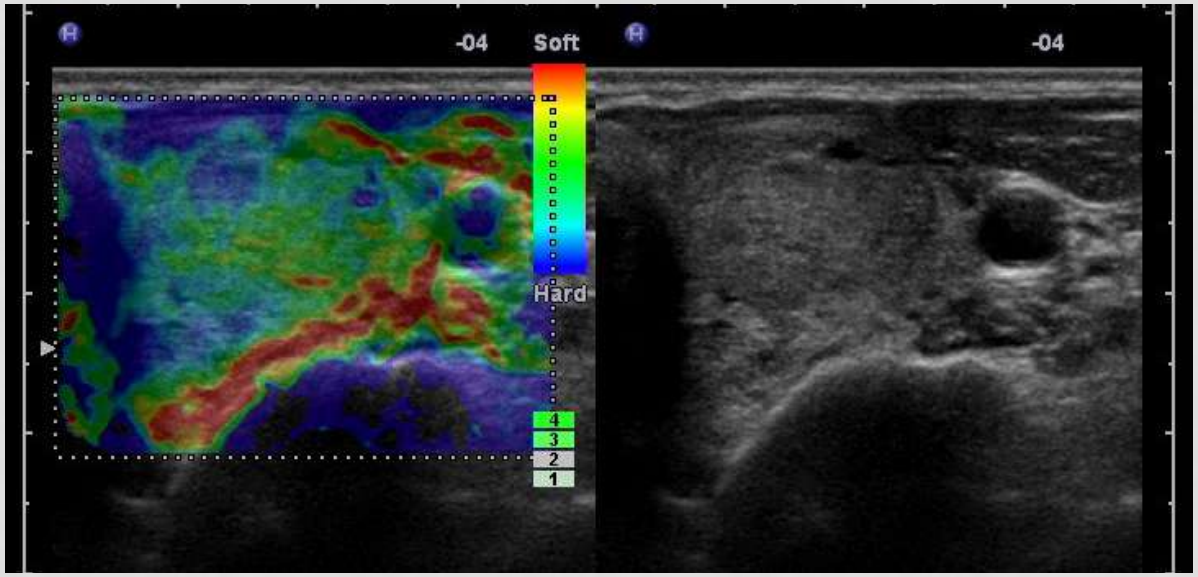
P. Mehrotra*, A. McQueen*, S. Kolla*, S. J. Johnsont and D. L. Richardson*

*Department of Radiology and †Department of Cellular Pathology, Newcastle upon Tyne, UK

99.1% NPV for 'SOFT' lesions

- 98% Rago (2007)
- 98.2% Asteria (2008)
- 94.5% Rubaltelli (2009)

Qualitative elastogram



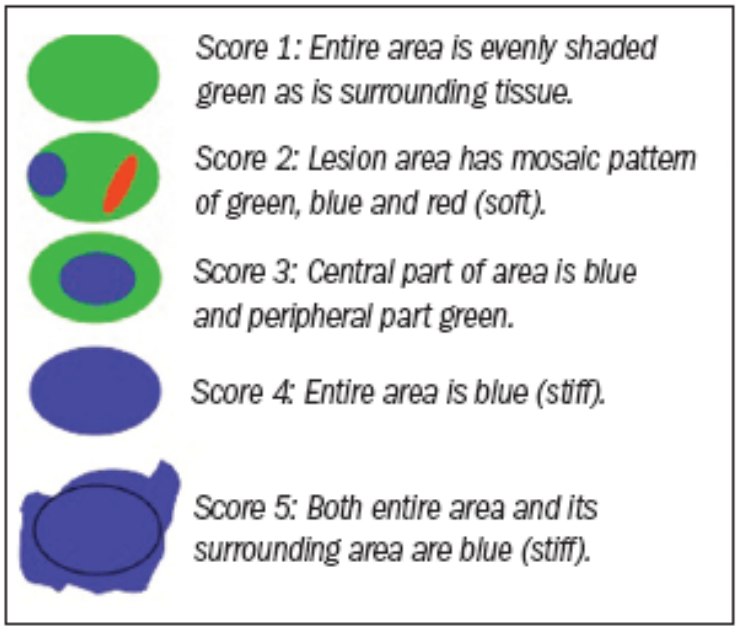
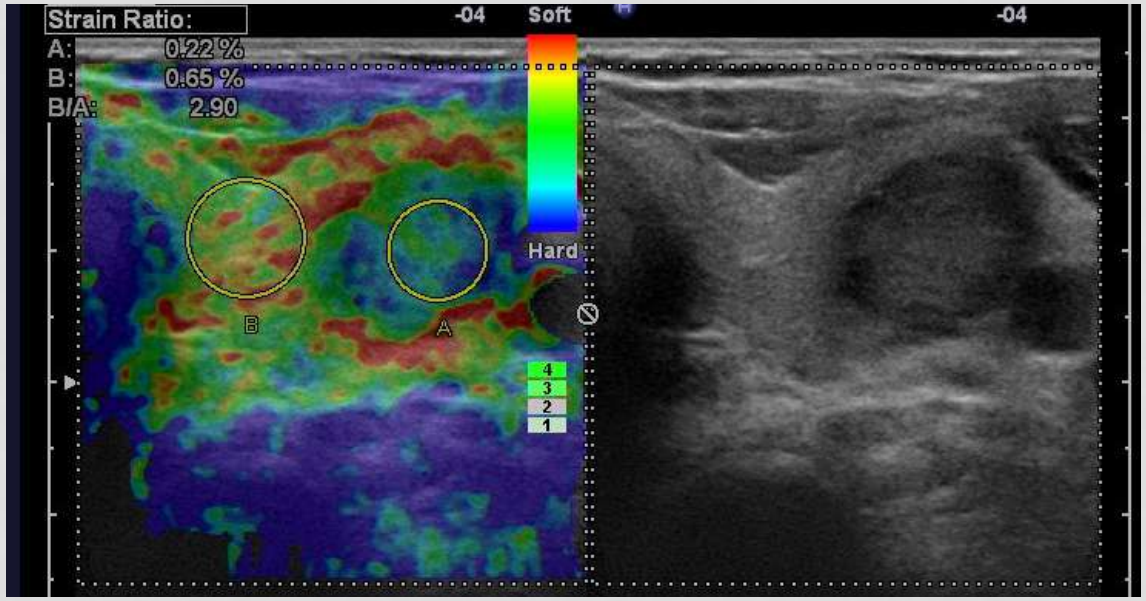


FIGURE 3. Ueno classification (Hitachi software).

STRAIN ELASTOGRAPHY - *ASSESS*

Quantitative elastogram



STRAIN VALUE

- ROI measure of strain
- Lower SV = STIFF

Vorländer 2010

- <0.15 HARD
- 0.15-0.3 INTERMEDIATE
- >0.3 SOFT

'SOFT' = 100% NPV

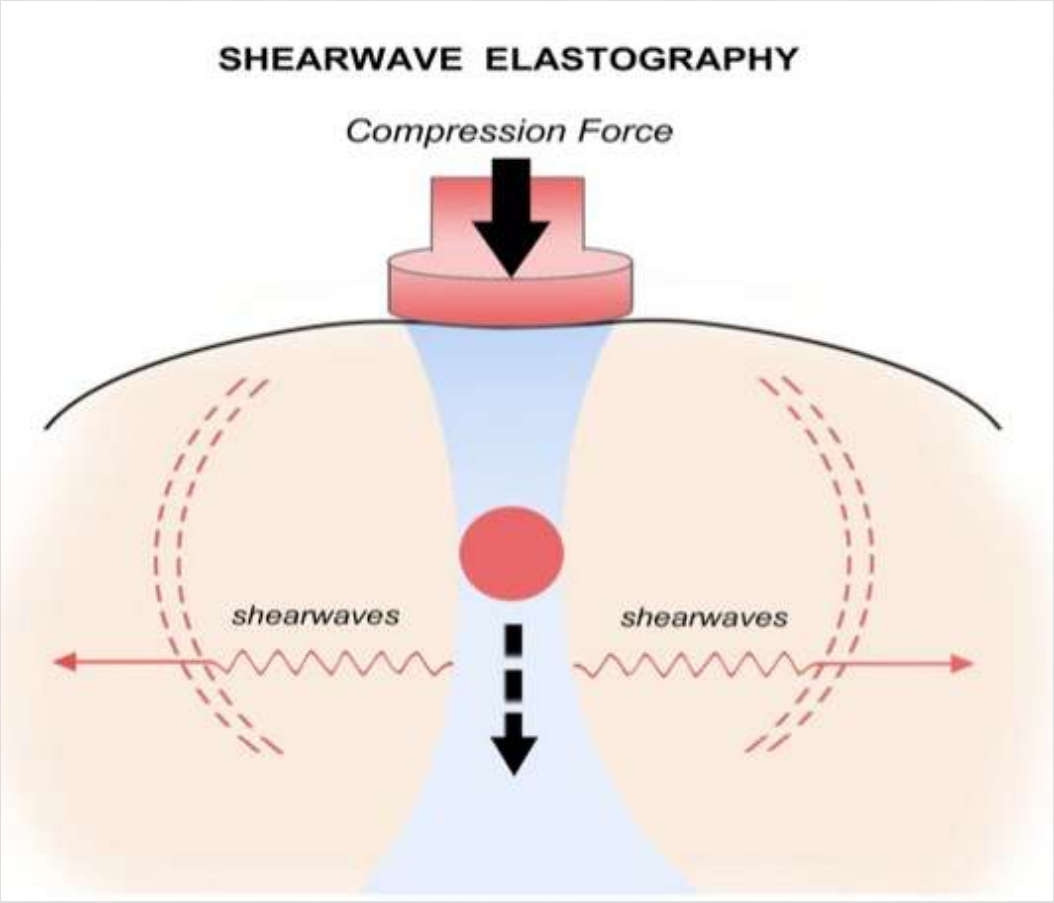
STRAIN RATIO

- Normal tissue/lesion strain ratio (B/A)
- Higher SR = STIFF

Cantisani 2012

- SR >2.0 HARD
- 97.3% sensitivity
- 91.7% specificity

SHEAR WAVE - *TECHNIQUE*



Lateral sound wave propagation = SHEAR
Higher velocity = Stiff lesion

Shear wave examples

- SWE (Supersonic Imagine)
- Acoustic radiation force imaging 'Virtual Touch' (Siemens)

SHEAR WAVE - *ASSESS*

Siemens Acoustic Radiation Force Imaging™ (ARFI)

- Point shear wave quantification
- Higher velocity (m/s)= STIFF
- 95.95% NPV (Gu 2012)

J Ultrasound Med. 2012 May;31(5):763-71.

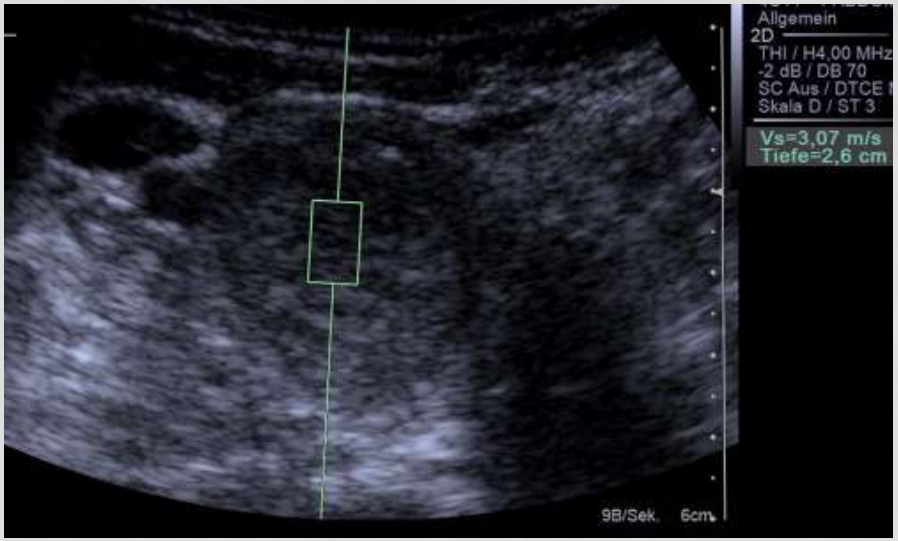
Preliminary study on the diagnostic value of acoustic radiation force impulse technology for differentiating between benign and malignant thyroid nodules.

Gu J, Du L, Bai M, Chen H, Jia X, Zhao J, Zhang X.

PLoS One. 2012;7(8):e42735. Epub 2012 Aug 29.

Acoustic radiation force impulse imaging for differentiation of thyroid nodules.

Bojunga J, Dauth N, Berner C, Meyer G, Holzer K, Voelkl L, Herrmann E, Schroeter H, Zeuzem S, Friedrich-Rust M.



SHEAR WAVE - *ASSESS*

Supersonic Imagine

ShearWave Elastography™

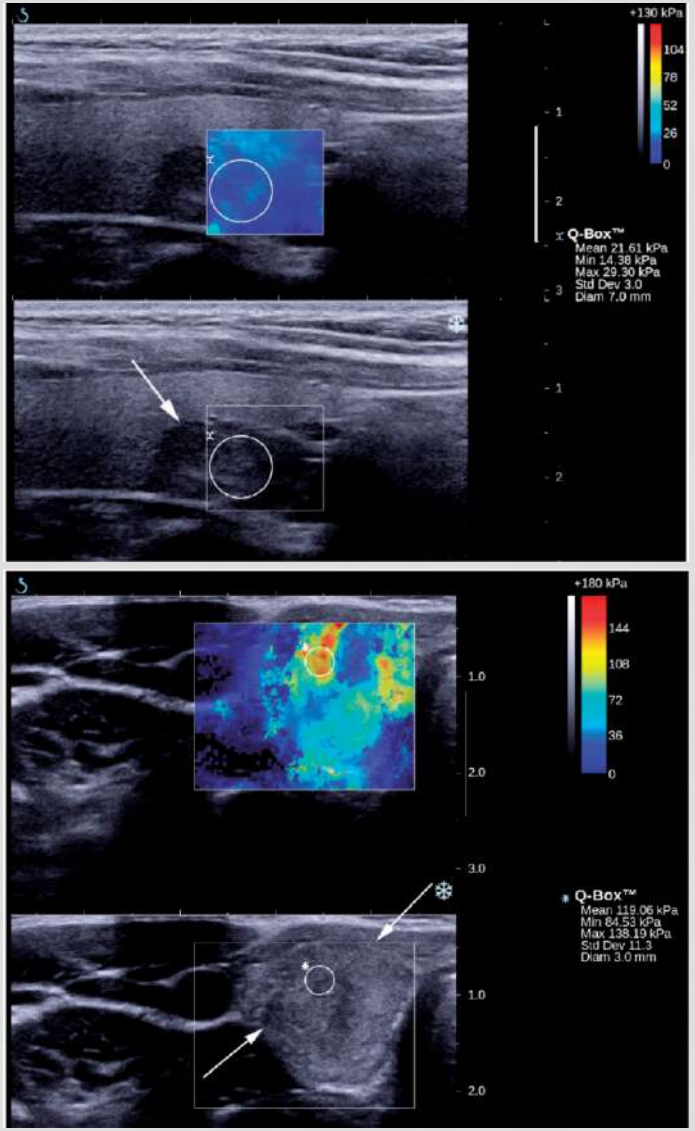
- Velocity of shear wave = kPa
- Higher kPA = STIFFER

66kPa cut-off (Veyrieres 2012)

- 297 nodules (35 cancers)
- Sensitivity 80%
- Specificity 90.5%

BUT…when combined with abnormal B mode features

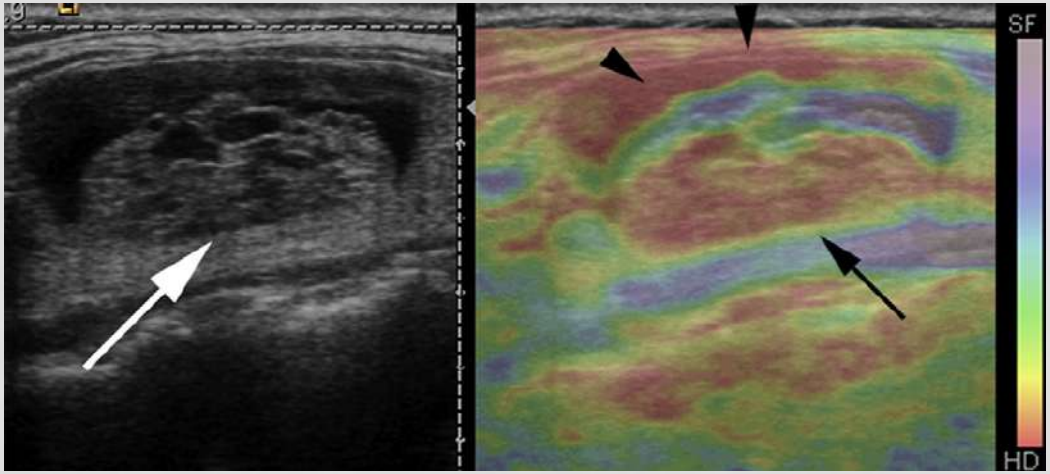
- 97% sensitivity, NPV 99.5%

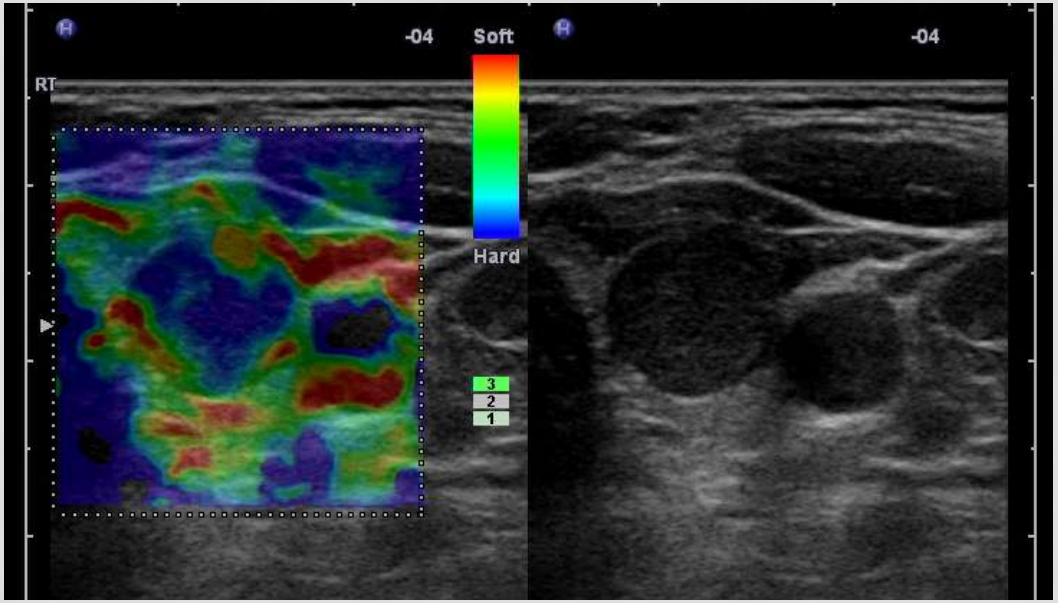


ELASTOGRAPHY *LIMITATIONS*

- Excluded nodules
  - Cystic, calcified, <1cm
- Thyroiditis = stiff
  - 'Normal thyroid' reference
- Follicular lesions
- Inter-observer variation

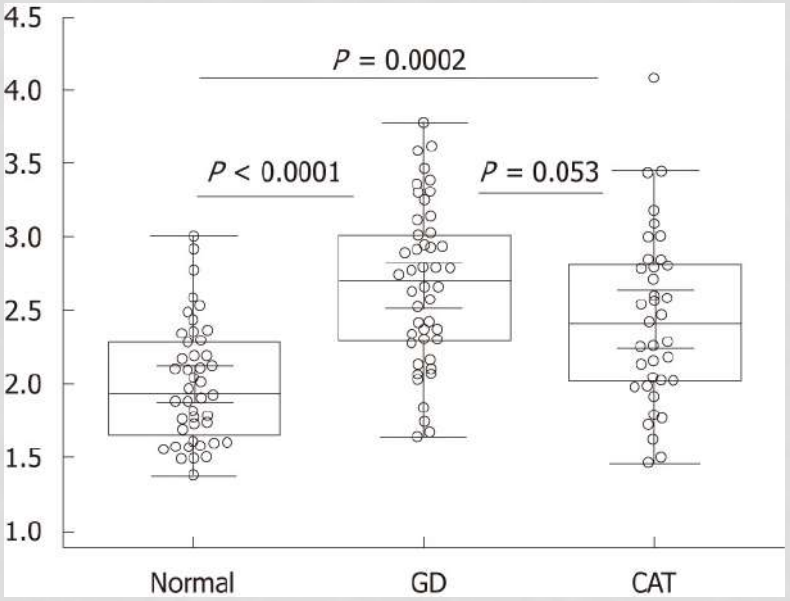
K.S.S.Bhatia et al. Clinical Radiology 66 (2011) 799-807





ELASTOGRAPHY
OTHER USES IN THE NECK?

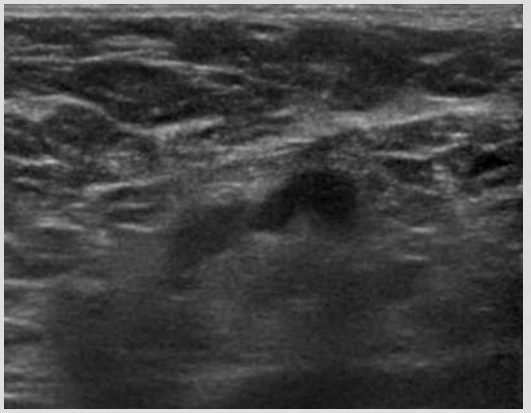
- Diffuse thyroid disease
- Salivary masses
  - Benign/malignant overlap
- Lymph node analysis
  - Useful in the axilla
  - ?role in the neck

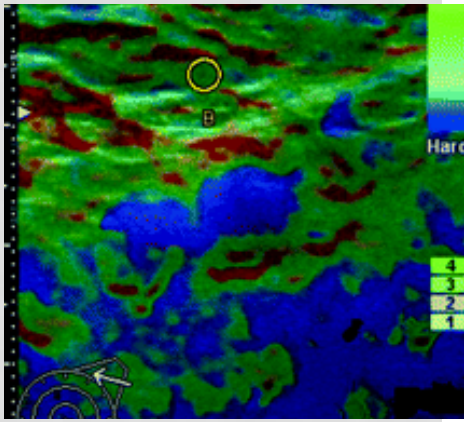


RESEARCH ARTICLE Open Access

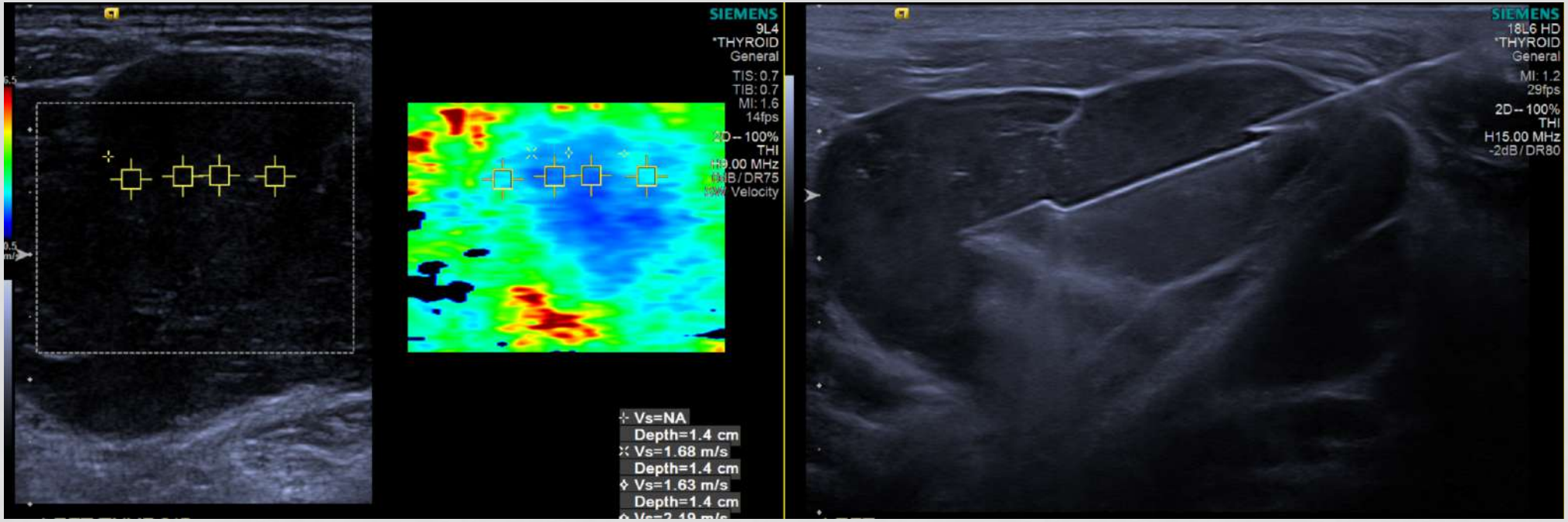
Real-time ultrasound elastography in 180 axillary lymph nodes: elasticity distribution in healthy lymph nodes and prediction of breast cancer metastases

Sebastian Wojcinski[1*†], Jennifer Dupont[2†], Werner Schmidt[3], Michael Cassel[4] and Peter Hillemanns[1]



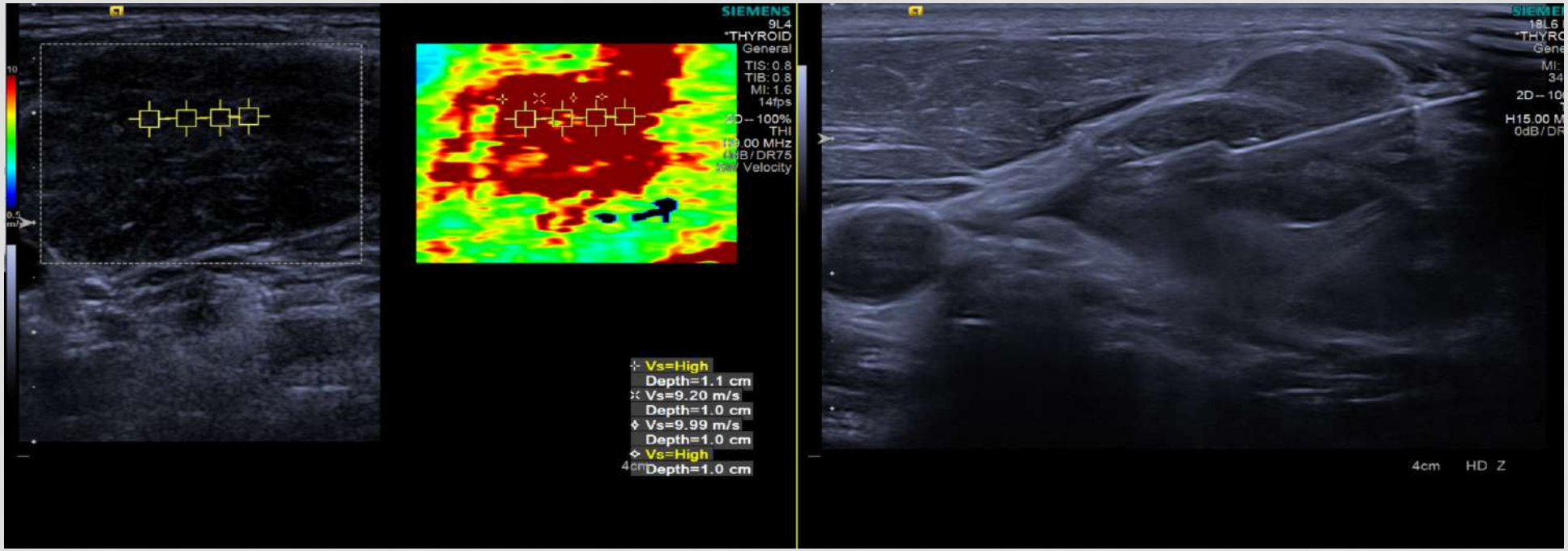


ELASTOGRAPHY
OTHER USES IN THE NECK?



Metastatic seminoma

ELASTOGRAPHY
OTHER USES IN THE NECK?



Metastatic moderately differentiated SCC
(Human papilloma virus positive)

ELASTOGRAPHY *FUTURE*

Designated role

- ElaTION study
  - Use of elastography to guide FNA

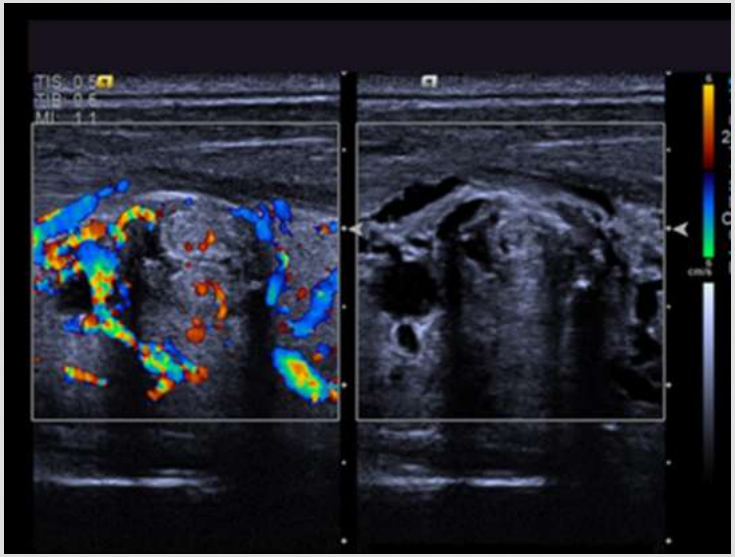
Standardised approach

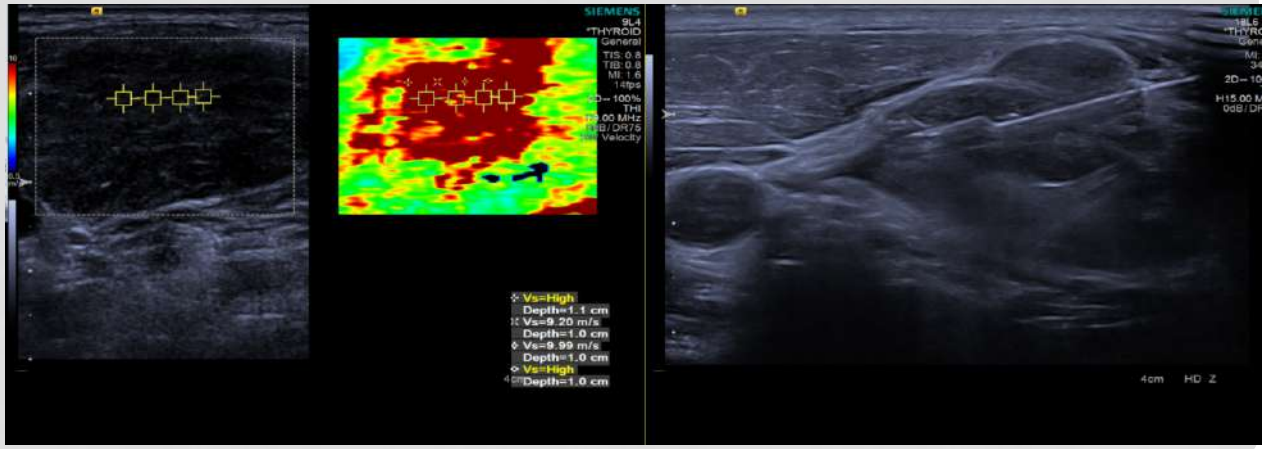
- Quick & Reproducible, reliable

Integration with Anatomic US

- Elastography improves B mode (TI-RADS) sensitivity & NPV

Provide new info..



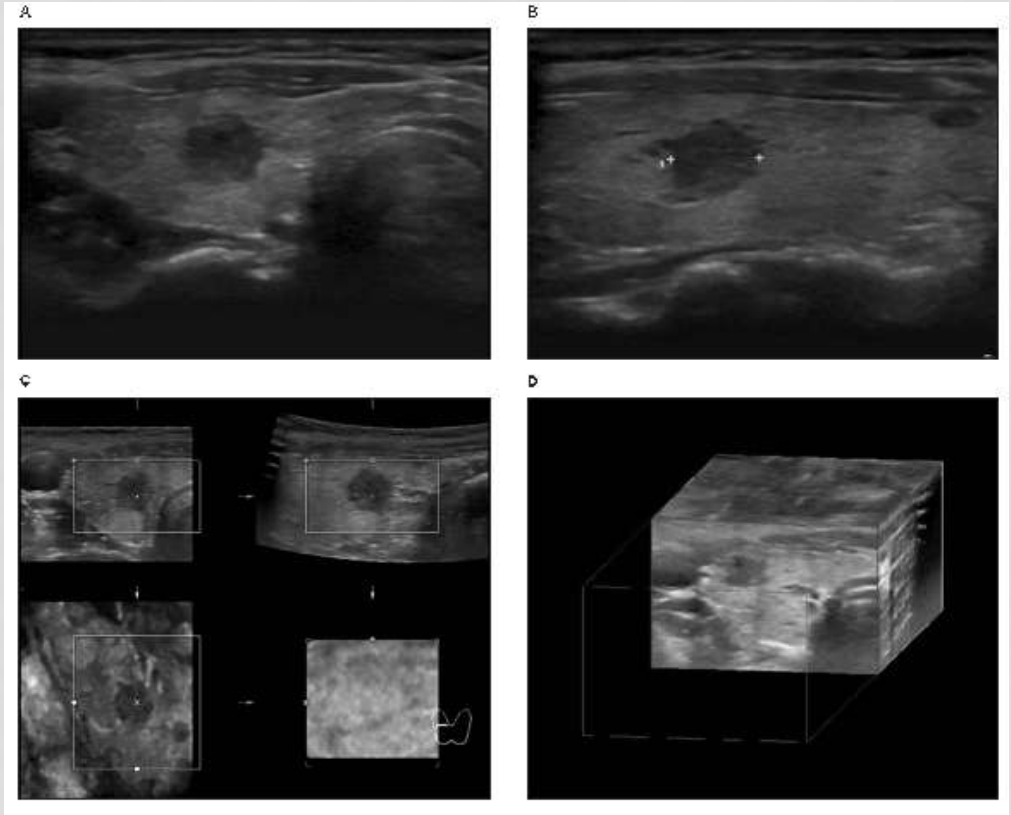


3D ULTRASOUND

Differentiating Benign From Malignant Thyroid Nodules

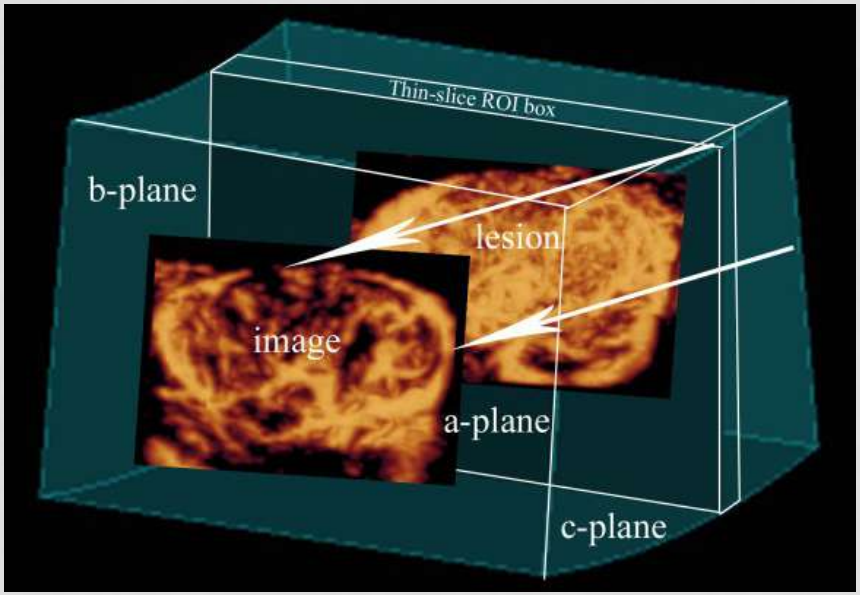
Comparison of 2- and 3- Dimensional Sonography

Mijung Jang, MD, Sun Mi Kim, MD, Chae Yeon Lyou, MD, Byung Se Choi, MD, Sang Il Choi, MD, Jae Hyoung Kim, MD



3D Ultrasound (LOCIQ 9 GE)

- Improved nodule delineation & interobserver agreement



Advantages and disadvantages of 3D ultrasound of thyroid nodules including thin slice volume rendering

Rafal Zenon Slapa[1*], Wieslaw Stanislaw Jakubowski[1], Jadwiga Slowinska-Srzednicka[2], Kazimierz Tomasz Szopinski[1,3]

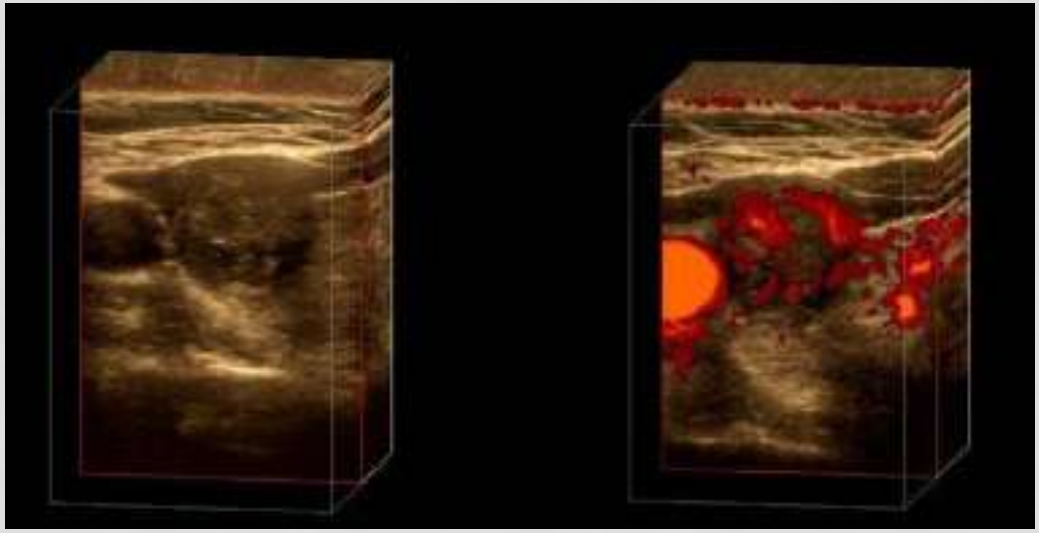
3D Computer Aided Diagnosis

Non-invasive automated 3D thyroid lesion classification in ultrasound: A class of ThyroScan™ systems

U. Rajendra Acharya[a], S. Vinitha Sree[b], M. Muthu Rama Krishnan[a], Filippo Molinari[c], Roberto Garberoglio[d], Jasjit S. Suri[b, e]

Detailed analysis of HRUS anatomical data

- Segmentation
- Feature extraction



Deep Learning

Deep Learning/ Artificial Intelligence

- Clinical Decision Support e.g. Samsung S Detect
- In-platform semi-automated lesion analysis
- Objective, reporoducible

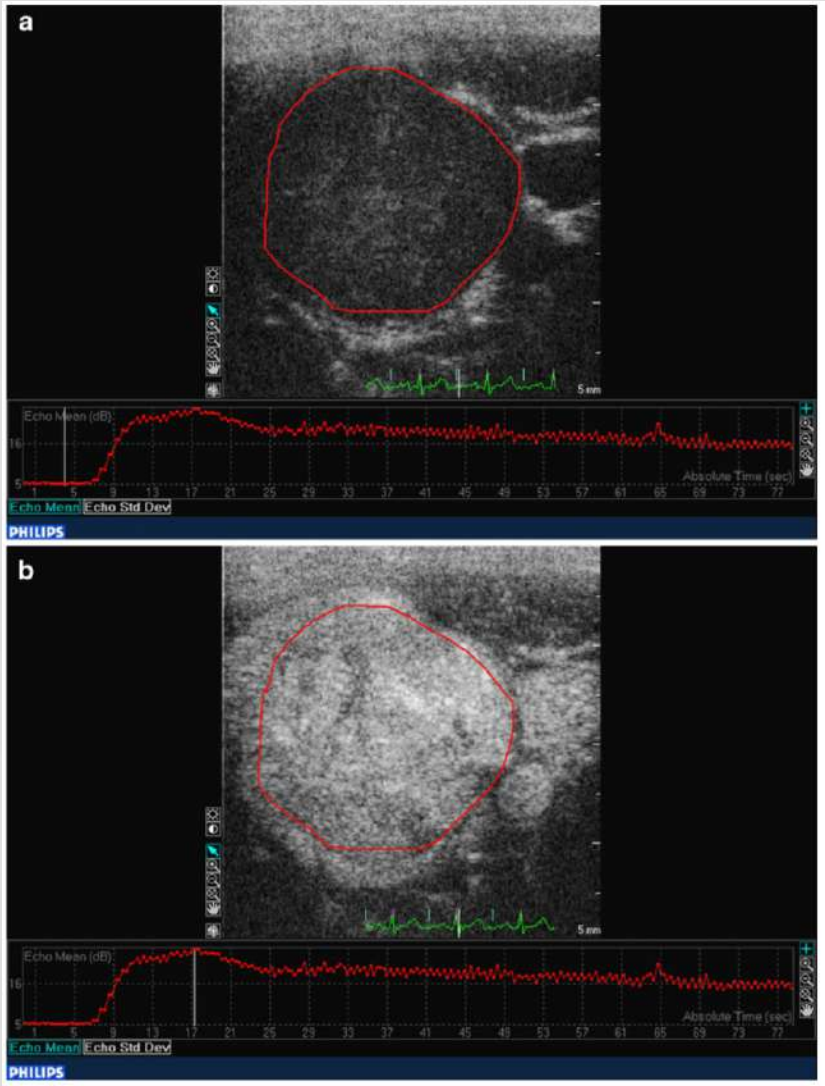
CONTRAST ENHANCED US

Eur Radiol (2012) 22:1357–1365
DOI 10.1007/s00330-012-2385-6

ULTRASOUND

Quantitative evaluation of contrast-enhanced ultrasound after intravenous administration of a microbubble contrast agent for differentiation of benign and malignant thyroid nodules: assessment of diagnostic accuracy

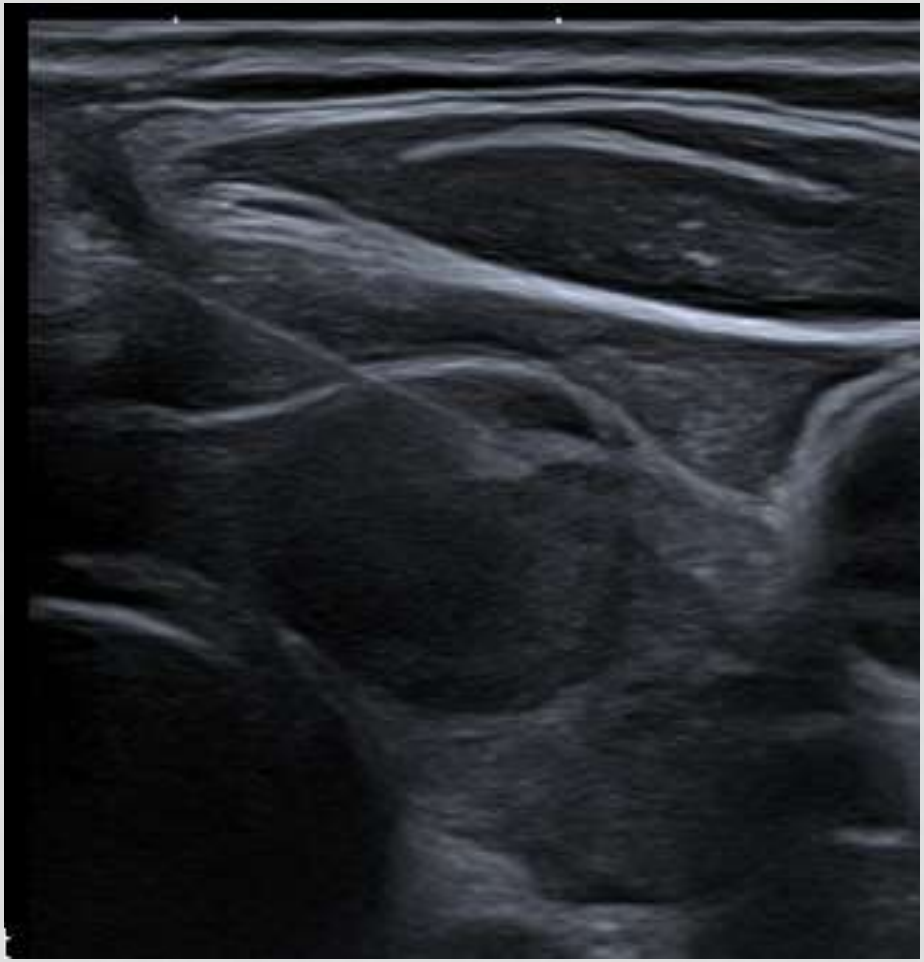
Ursula Nemec · Stefan F. Nemec · Clemens Novotny · Michael Weber · Christian Czerny · Christian R. Krestan



CEUS for thyroid nodules

- Nemec 2012, 42 patients
- Higher peak enhancement in malignant nodules

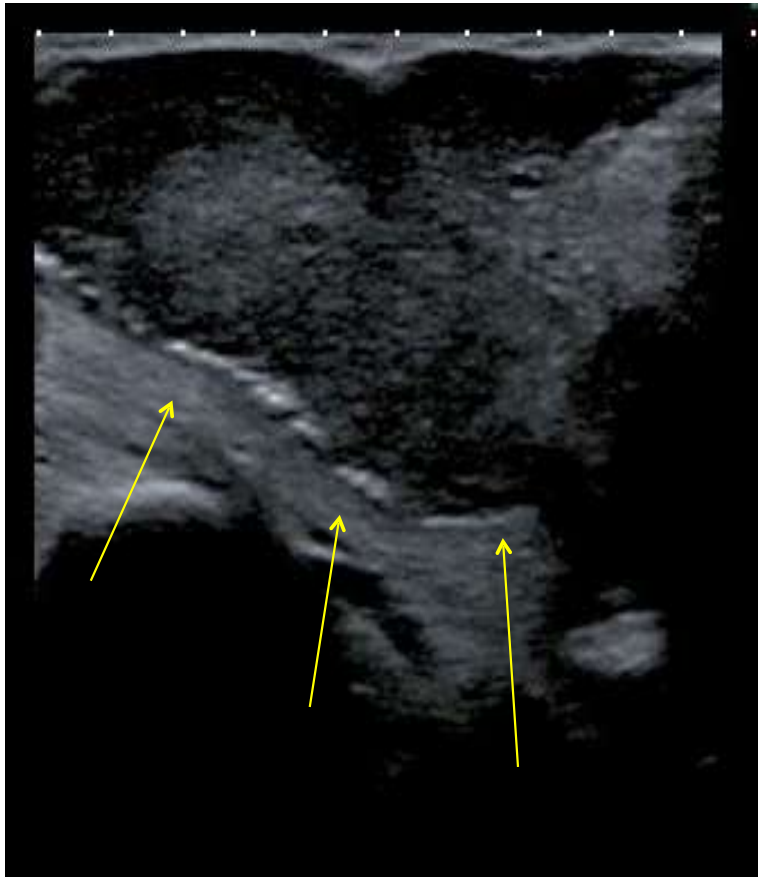
Perfusion Map without the bubbles?

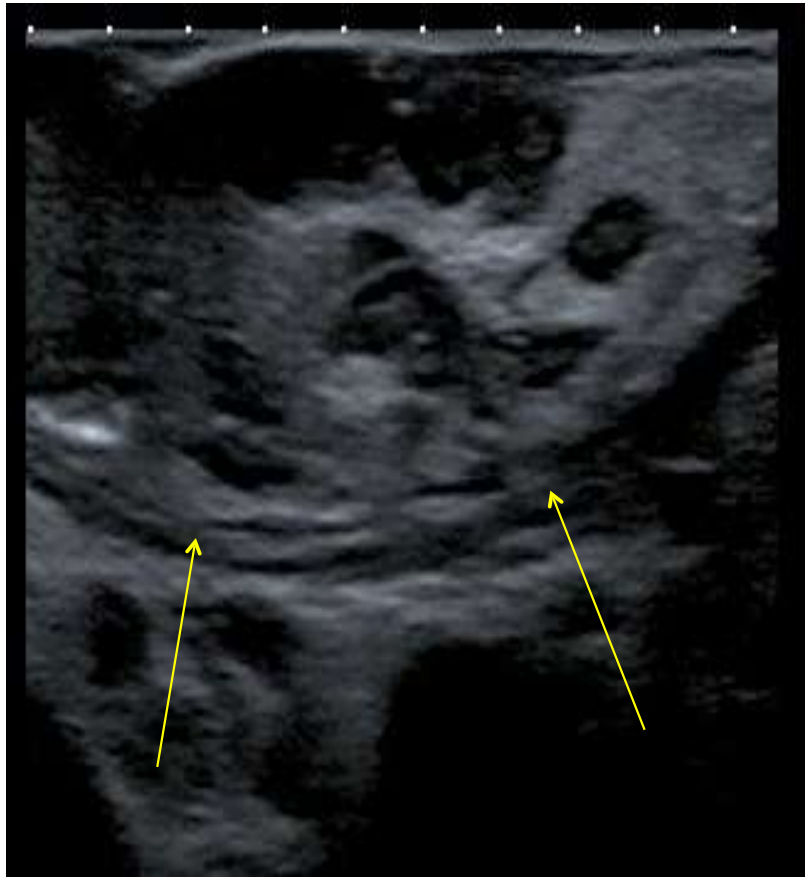


Future Uses:

Intra-oral US

Patient Selection – *Tonsillar tumours*



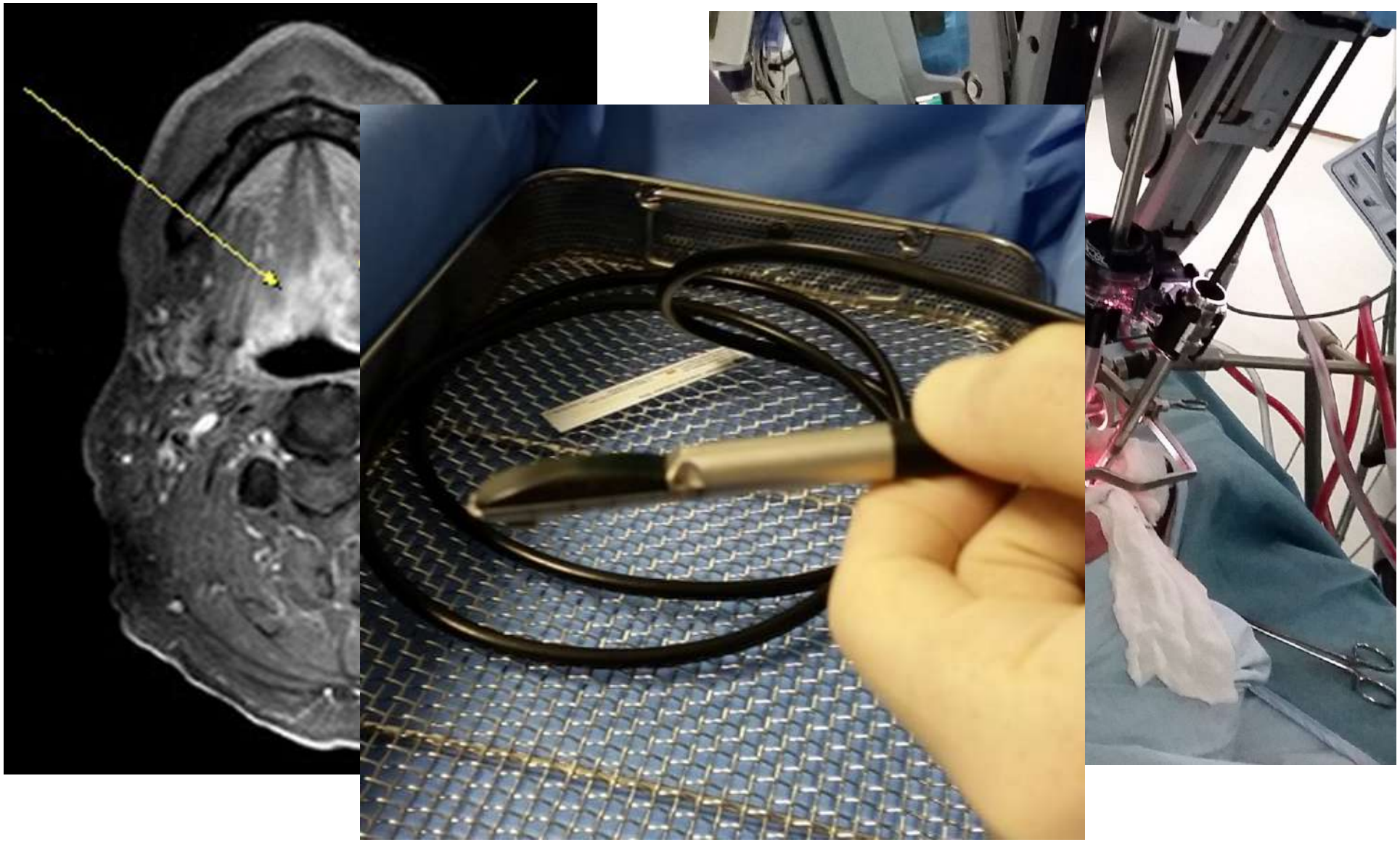


Intraoral ultrasound of tonsillar mass – no involvement of constrictor muscle = ***TORS CANDIDATE****

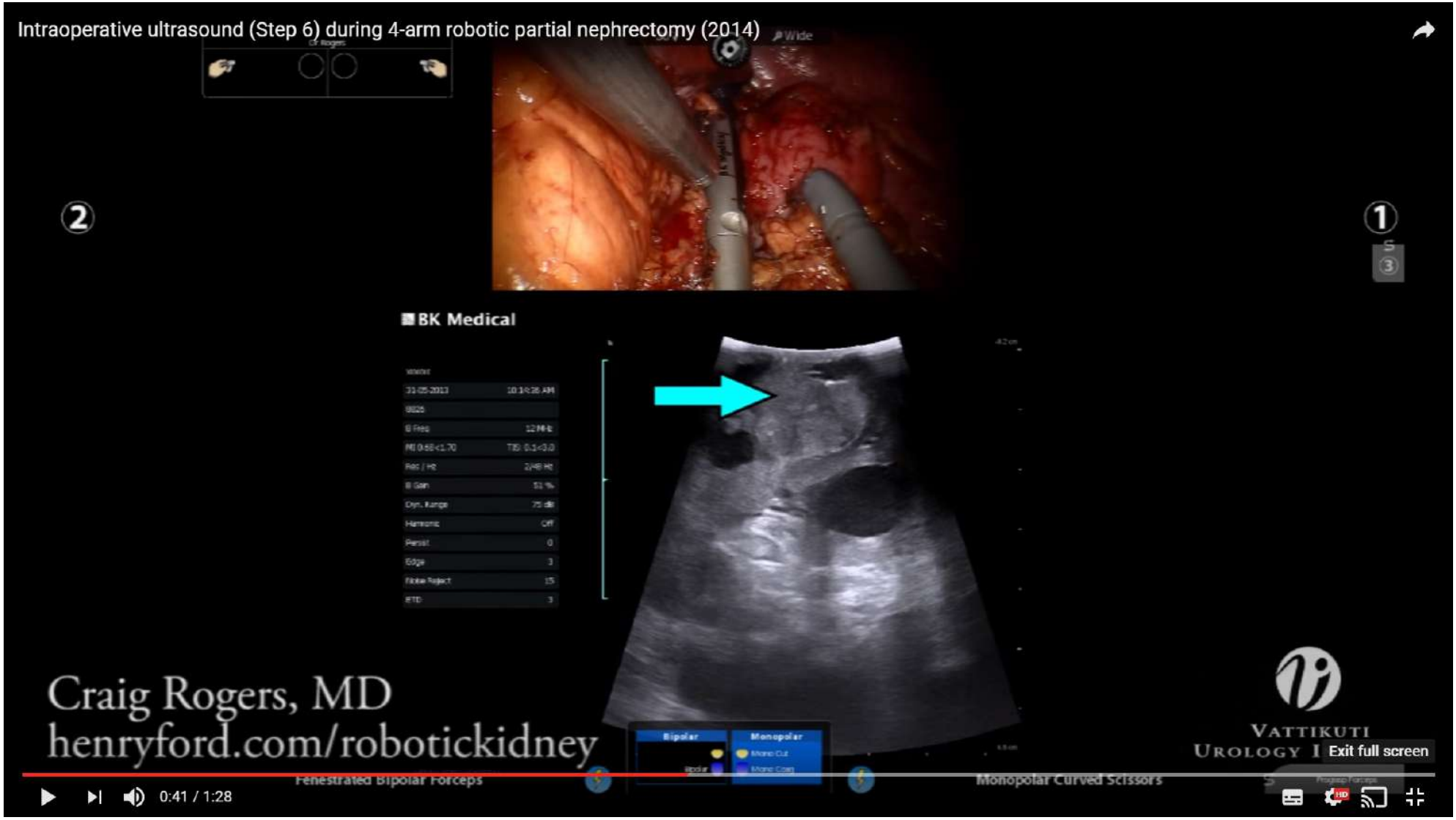
Future Uses:

Intra-operative guidance

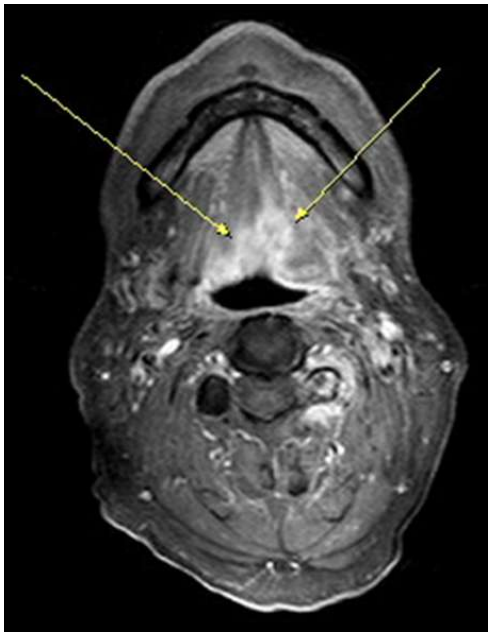
Intra operative guidance – *Tumour delineation*

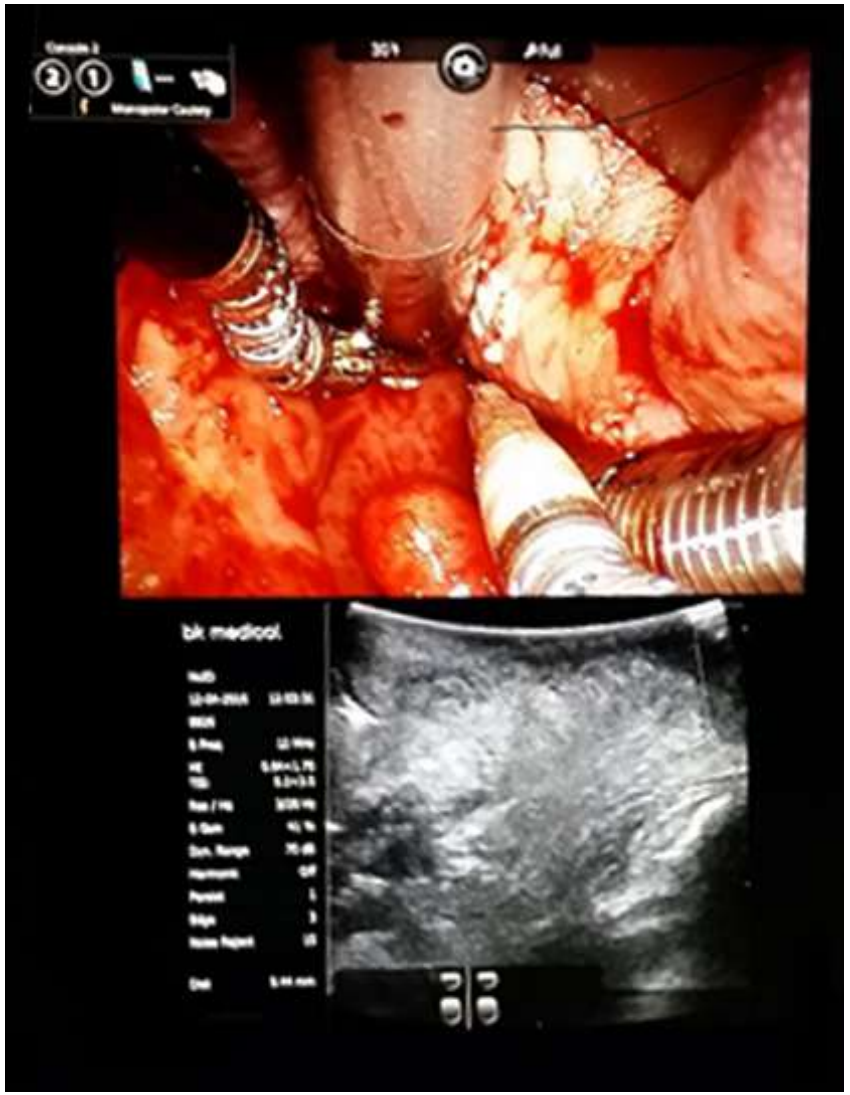


Endophytic RCC partial nephrectomy



Intra operative guidance – *Tumour delineation*

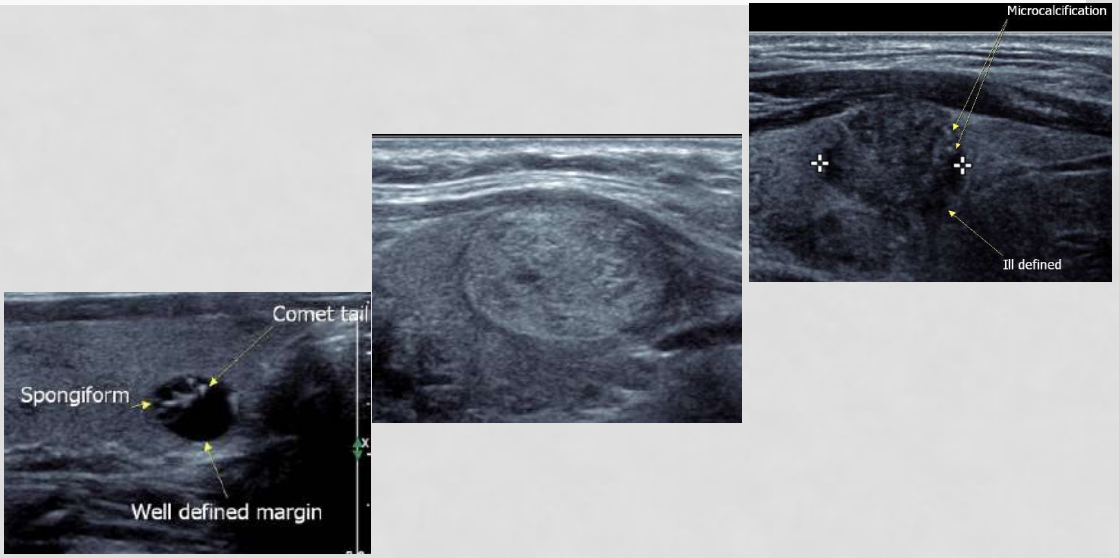


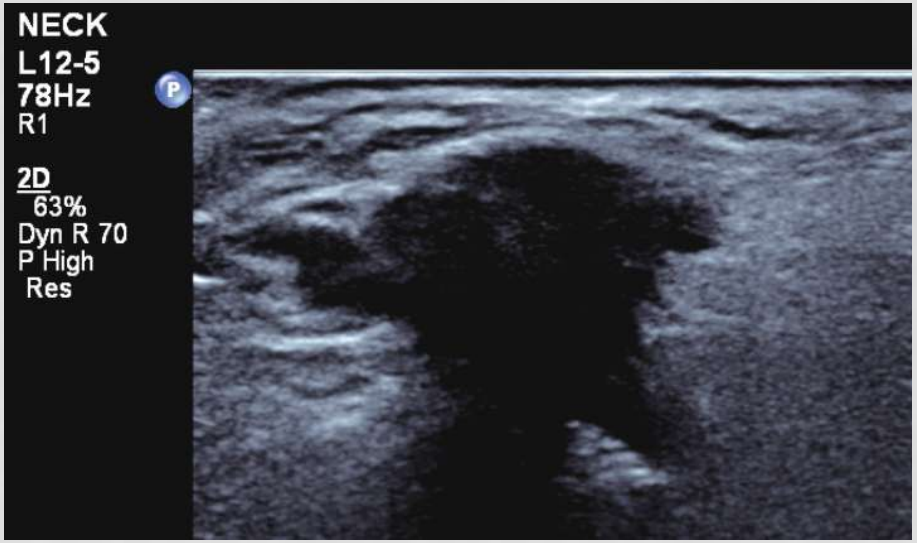


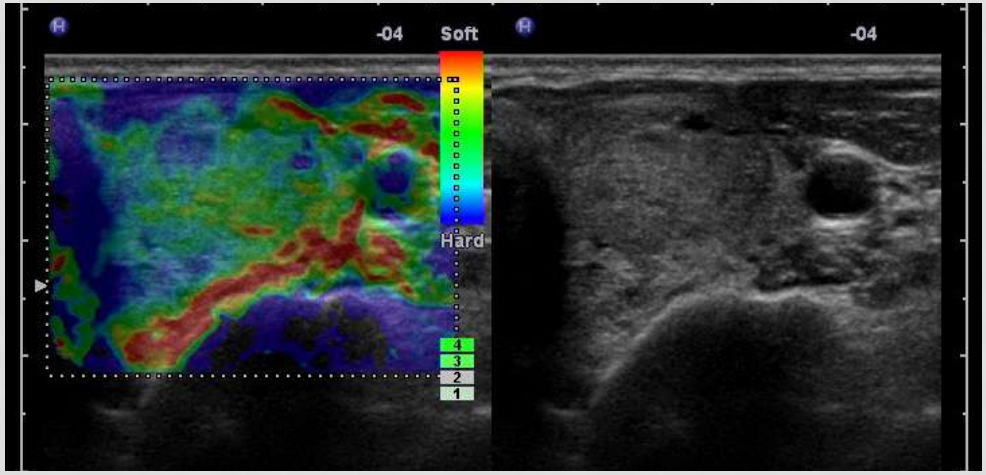
ADVANCES IN NECK ULTRASOUND

High Resolution Ultrasound

- Superb anatomical detail
  - Thyroid, Lymph nodes, Salivary masses
  - Congential cysts
- Elastography role emerging
- Novel applications appearing
- Remember technical factors







RSM professionals
Unique learning experiences

bshni

Head and neck imaging refresher course 2018

Date: Friday 9 February 2018

Venue: Crowne Plaza Newcastle,
Stephenson Quarter, Forth St, Newcastle Upon Tyne, NE1 3SA

CPD: (applied for)

Topics for this year:
- Otology and skull base
- Sinuses and nasopharynx
- Laryngology and hypopharynx

This one day course features focused presentations from leading UK head and neck radiologists with plenary discussion of hot topics and interactive workshops to allow interactive learning.


Thank you
FreeFoto.com