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 & evidence base in the neck

- Emerging roles & new ideas
  - Transoral US
  - Perfusion & Contrast enhanced US
  - The rise of Al..
HIGH RESOLUTION THYROID US

1981: 5MHz linear array
HIGH RESOLUTION THYROID US

1981: 5MHz linear array
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 Mosco, MD

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

Biopsy of Thyroid Nodules: Comparison of Three Sets of Guidelines

US Features of Thyroid Malignancy: Pearls and Pitfalls

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

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

Indications for Fine Needle Aspiration in Thyroid Nodules

By Young Kwak
How most people feel about thyroid nodules....
MARGINS

- Ill defined
- 53-89% sensitivity
- Irregular, spiculated
- 92% spec, 81% PPV
- Extrathyroid breach
Technical point
- Higher frequencies
- Wider bandwidths
- Spatial compounding

MARGINS*
*Worst Agreement
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
BTA 2014 NODULE CLASSIFICATION
HIGH RESOLUTION US:
Detailed anatomical characterisation
High Resolution US: Seeing more – changing management

HIGH RESOLUTION US:
Seeing more – changing management
MDT Question: Is this right laryngeal tumour just into thyroid cartilage (T3) or does it show extralaryngeal spread (T4)?
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

Thyroglossal Duct Cyst
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

Does elastography reduce the need for thyroid FNAs?

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

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

Qualitative elastogram

99.1% NPV for ‘SOFT’ lesions
- 98% Rago (2007)
- 98.2% Asteria (2008)
- 94.5% Rubaltelli (2009)
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)
Siemens Acoustic Radiation Force Imaging™ (ARFI)
• Point shear wave quantification
• Higher velocity (m/s) = STIFF
• 95.95% NPV (Gu 2012)

Preliminary study on the diagnostic value of acoustic radiation force impulse technology for differentiating between benign and malignant thyroid nodules.
Gu J, Du L, Bu J, Chen H, Lu X, Zhao J, Zhang Z.

Acoustic radiation force impulse imaging for differentiation of thyroid nodules.
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

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
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

3D Ultrasound (LOCIQ 9 GE)

- Improved nodule delineation & interobserver agreement

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

Natal Zenon Szaba, Wieslaw Stanislaw Jakubowski, Jadwiga Slowinska-Szczepniak, Kazimierz Tomasz Szopinski
3D Computer Aided Diagnosis

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

U. Rajendra Acharya³, S. Vinitha Sree⁵, M. Muthu Rama Krishnan³, Filippo Molinarì⁵, Roberto Garberoglio⁴, Jasjit S. Suri⁵, *

Detailed analysis of HRUS anatomical data

• Segmentation
• Feature extraction
Deep Learning

S-Detect User Interface on RS80A with Prestige

- S-Detect recognizes lesion and offers candidate contours
- Users can mark position of lesion along with additional information
- S-Detect provides suggestions on classification criteria; users can easily check and make changes if necessary
- Users can choose appropriate contour using touch screen panel
- S-Detect provides recommendation on whether the selected lesion is benign or malignant
Deep Learning/Artificial Intelligence

- Clinical Decision Support e.g. Samsung S Detect
- In-platform semi-automated lesion analysis
- Objective, reproducible
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
- Elastogaphy role emerging
- Novel applications appearing
- Remember technical factors
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