Developing a Non Ionising Scope of Practice for Clinical Technologists

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In 2019 the Register of Clinical Technologists (RCT) opened the door to developing new scopes of practice, and published guidance notes setting out what was needed to take a proposal forward[1]. An IPEM Working Party was formed to develop a proposal for a Non Ionising Radiation and Ultrasound Technologist Scope of Practice. The Working Party comprised members of the IPEM Ultrasound and Non Ionising Radiation Special Interest Group (IPEM UNIR-SIG) and other Clinical Technologists and Scientists representing Ultrasound and Optical Radiation specialities from across the UK. The IPEM Magnetic Resonance Special Interest Group (IPEM MR-SIG) then approached us about working on a combined proposal and we are working together to take this forward.

The key tasks being undertaken by the working party include:

1. Review existing workforce data and identify areas where further information is required
2. Search for, and review key national standards, guidance and legislation on quality and safety requirements for the relevant equipment and services
3. Develop risk matrix to identify key hazards due to poor quality training
4. Define the scope of practice of the job roles and basic competence levels including knowledge and understanding required for a technologist to be safe and effective
5. Review existing educational courses and identify any training and development needs that have to be developed
6. Develop the equivalence route documentation; standards / evidence matrix and portfolio guidance

This presentation will provide an update of the working party's progress and the work still ongoing.

Registration is an important tool to assure patients and the public, as well as employers that Clinical Technologists are appropriately qualified and work to a defined set of professional standards. Having a dedicated Non Ionising scope of practice allows the profession to set a benchmark defining minimum standards to ensure that non ionising technologists are knowledgeable and competent to carry out their role. It will improve visibility of the specialism and should provide stimulus for the development of training pathways and career frameworks for non-ionising technologists, helping with potential recruitment issues and support the retention of expertise and experience.

References

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An update from the BMUS Physics & Safety group.

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Background.

The membership of the British Medical Ultrasound Society is primarily composed of Sonographers, Radiologists, Obstetricians, Emergency Physicians, Physicists, Cardiologists, mid-wives and equipment manufacturers. The objectives of the society are:-

- the advancement of ultrasonics applied to medicine,
- maintenance of high standards in these fields,
- advancement of education and research in these areas
- the provision of advice and information regarding ultrasound to the public.

The structure of the Society consists of Officers, The Council and the Science & Education Committee. The S&E committee oversees the activities of a number of groups, including the Physics and Safety Group. This talk will summarise some of the recent work that the BMUS Physics and Safety Group have provided contributions to.

The topics discussed in this presentation cover safety of ultrasound, governance in ultrasound and upcoming work.
BMUS survey on awareness of safety indices.
BMUS / BAPM guidelines on neonatal scanning
ECMUS / BMUS recommendations on Lung Ultrasound scanning
RCR / BMUS guidelines on POCUS
AXREM / BMUS / IPEM guidance on purchase of pre-owned ultrasound equipment.

Low-Cost Doppler US Phantom – An In-Use Review

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Background:

Ultrasound (US) techniques for clinical diagnostic imaging are continually developing, but as a consequence more reliable and representative quality assurance (QA) tests must be introduced as standard to ensure the best patient care (Dudley, et al., 2010). However, there continues to be a lack of consistency and agreement in US QA procedures across NHS trusts (Sassaroli, et al., 2019; Browne, 2014).

This issue is particularly evident when considering Doppler US. There are several types of Doppler phantoms available, but these are often associated with high costs and difficulty of use, resulting in Doppler US performance at times being overlooked during QA. A recent proposal by David Rowland (Leeds Teaching Hospitals NHS Trust) (Rowland, n.d.) worked to bridge this issue by introducing a new test device based on a simple vibrating audio driver, providing a low-cost and portable Doppler phantom for use in Doppler US QA. This work utilises the Doppler phantom suggested by David Rowland, and aims to provide insight into the efficacy of the phantom for QA testing.

Methods:

Working collaboratively with the University Hospitals Birmingham NHS Foundation Trust and Leeds Teaching Hospitals NHS Trust, physics staff at the University Hospitals of North Midlands (UHNM) used the in-house Doppler phantom suggested by David Rowland to monitor Doppler performance of clinical US scanners. Routine tests were agreed between trusts, resulting in the decision to measure mean velocity from 1 kHz and 2 kHz tones, and peak systolic velocity (PSV), end diastolic velocity (EDV), pulsatility index (PI), resistivity index (RI) and heart rate from a 2.0 – 0.5 kHz sweep with 1 second sweep time. The results are collated as part of a collaborative worksheet, and used to assess the efficacy of using the phantom for the routine interrogation clinical scanners.

Results:

The results will be continually acquired leading up to the conference and discussed at the time of presentation. Briefly, this will include an overview of how the phantom was used alongside the results and feedback acquired from users across different trusts and scanners.

Conclusion:

This work hopes to demonstrate the practical use of the low-cost Doppler US phantom suggested by David Rowland, providing an overview of routine Doppler US QA tests performed on clinical US scanners. It is hoped that this work will help to provide a simple approach to deal with the current lack of consistency for Doppler US testing, thereby providing a more robust scanner QA across the NHS and consequently allowing improved patient care.

Key Words: *Ultrasound (US), Doppler, Phantom, Quality Assurance (QA)*

Key references:

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Feature identification in lung ultrasound imaging using machine learning

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Background: The use of artificial intelligence, such as machine learning (ML), with medical imaging is a highly active area of research as it may be able to improve image acquisition and automate aspects of the diagnostic pathway. During the COVID-19 pandemic, the predominant cause of death was due to hypoxaemic pneumonia, which was diagnosed using chest x-rays. While this imaging modality was the 'gold standard' for diagnosis, it came with complications such as infection risk to patients/staff, equipment access and the use of ionizing radiation. This led to a renewed interest in other modalities that could complement existing practice, such as lung ultrasound (LUS). As the B-mode images acquired when imaging the lung are mostly artefactual, their correct interpretation takes an experienced operator. The aim of this study was to implement a real-time ML algorithm that could identify the key features associated with COVID pneumonia, and compare it with expertly labelled images.
Methods: Datasets from both simulated and clinical images were used in this study. These were acquired using a range of GE LOGIQ ultrasound scanners (S8, E10). The simulated datasets were generated by a senior radiographer scanning the CAE Blue Phantom COVID-19 Lung Simulator. Cine loops were converted to single frames and combined with other still images to create a pool of approximately 13k images. A total of 500 images were randomly selected using MatLabs *randperm* function, which were then labelled by five users with a range of ultrasound expertise. Each user labelled, where relevant, the following features, 'ribs', 'pleural line', 'A-line', 'B-line', and/or 'B-line confluence' in 100 images using the VGG image annotator online tool. Pre-processing was performed prior to training, which included cropping (e.g., to eliminate scanner information), geometric transformations (horizontal axis flip and rotation) and ultrasound-specific augmentations (gain, TGC, and depth). Geometric transformation and augmentations were used to increase training set diversity and model robustness to a general ultrasound image. ML was performed using a lightweight version of the U-net architecture was used for multi-feature semantic segmentation, which was trained using a single GPU (NVIDIA RTX 3080 laptop). To evaluate model accuracy, the Dice coefficient was measured over three training split repeats, giving the similarity between the predicted masks, and manually labelled 'ground truth' masks provided by the radiographer.
Results: Figure 1 shows examples of (a) manually labelled images and those by the (b) ML algorithm for the range of features of interest in LUS images.

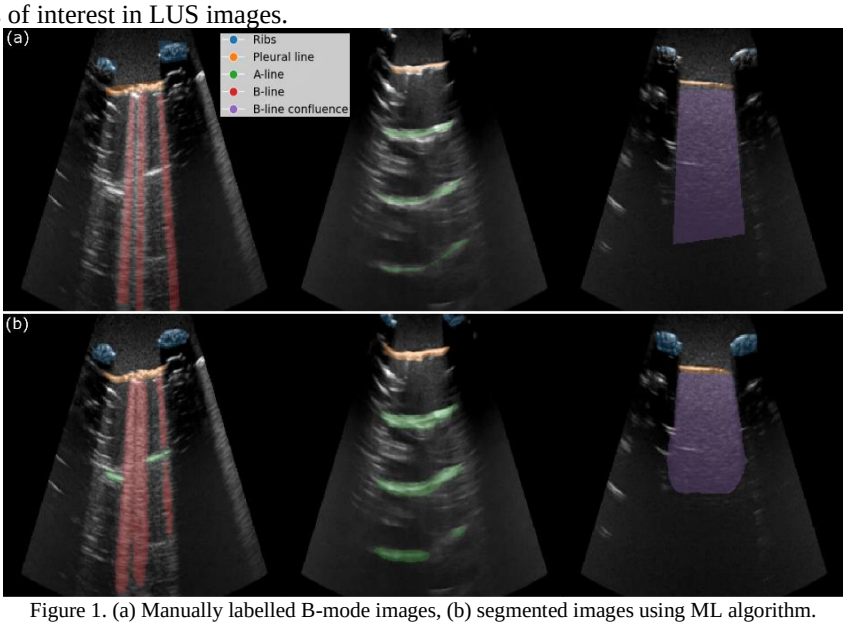

Figure 1. (a) Manually labelled B-mode images, (b) segmented images using ML algorithm.

When running the mean frame rate the segmentation was running at was 33 ±0.5 Hz, which was sufficient to run at real-time with the ultrasound imaging. However, while the Dice score for B-line confluence was over 70 %, successful predictions were reduced to 51 and 33 % for identifying B-lines and A-lines, respectively.
Conclusion: The use of ML for augmenting and helping to identify features in ultrasound images is highly dependent on the quality of labelled data used in training models. In this study we had success in identifying features associated with COVID-19 induced pneumonia, in real-time, using a training phantom, but accuracy could be improved through a more standardised approach to labelling training data.

Key Words: Lung ultrasound, Machine Learning, Image Segmentation, Real-time, COVID-19

Ultrasound QA in Northern Ireland: Experiences and challenges faced during a new service roll out.

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Background: The Regional Medical Physics Service in Northern Ireland started a new ultrasound physics support service in 2019. This abstract summarises the experiences and challenges faced during the roll out. A few cases of repetitive faults on similar probes are presented. Cases of unusual faults and experiences with interactions with manufacturers are discussed further.

Methods: NI has 5 main healthcare trusts and there are 22 hospitals with specific radiology departments. An up-to-date inventory of all ultrasound scanners which belonged to any screening programmes such as BSP, AAA and Fetal Anomaly and of all radiology scanners was established and acceptance and baseline testing was initiated on these scanners.

Results and Discussion: Approximately 35 % (39/111) of all probes tested had faults. 70% (7/10) of a particular probe from Manufacturer A were found to be faulty and needed replaced. Cable fault, shattered crystal and increased number of drop outs were some of the major faults repeatedly noticed. Several probes of similar kind from Manufacturer B were rejected due to similar damage to the surface coating [Fig 1] making it impossible to clean adequately, hence presenting a cross contamination risk. Rare faults such as variation in the lens thickness [Fig 2], axial bandings, improper functioning of speckle reduction imaging [Fig 3], washed out appearance of images [Fig 4] were also noticed.

Figure 1: Damaged Surface Coating

Figure 2: Lens Thickness Variation

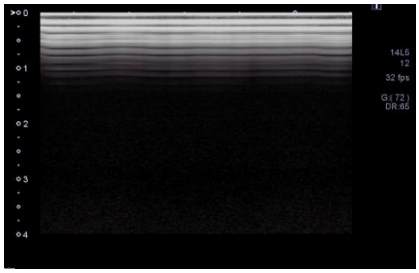


Figure 3: Improper functioning of speckle reduction imaging

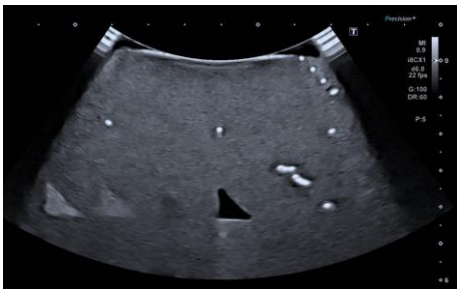
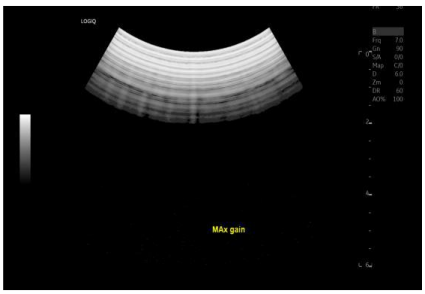


Figure 4: C2-9 Washed out image



Conclusion: Acceptance and Baseline testing protocols had to be adapted to address the fact that the scanners assessed had already been in use. User QA was also introduced in all radiology departments and has proven to be very effective in identifying faults sooner. As with any new service, the implementation period had its challenges. However, once embedded, the importance and effectiveness of ultrasound QA and the benefits of having medical physics support were recognised as being essential.

Ultrasound Imaging Quality Assurance (QA) Survey

Thomas Hughes

Background - IPEM Report 102 provides a range of tests and equipment that can be used to perform QA testing on ultrasound scanners [1]. However, time, budget and staffing constraints mean tests need be prioritised. Doubts have been raised whether extensive testing is useful [2], with over 90% of defects identified by an electronic probe tester being identified with a visual inspection of the probe and an image uniformity test [3,4,5]. However, a broad range of tests are considered helpful [6]. The aim of this study is to assess how ultrasound imaging QA testing is performed in practice.

Methods - A survey was distributed via the JISCMail MEDICAL-PHYSICS-ENGINEERING mailing list. Questions were aimed at identifying the equipment used, tests performed, frequency of testing, and the time taken per probe.

Results - The most common routine QA frequency among respondents is annual (50%).

The time spent per probe varies from 5-50 minutes. Large differences are seen even between respondents who perform similar testing.

The most popular equipment is a tissue-equivalent test object (92%), followed by an open-topped test object (33%). One respondent (8%) uses Doppler flow and string phantoms, an acoustic force balance, and a hydrophone for QA, but none of the other respondents uses any of these.

Three quarters (75%) of respondents do not perform display performance testing. B-mode testing is extensive, with only dead zone (42%) not being tested by the majority of respondents. Safety testing is limited, with most respondents performing only mechanical integrity (100%), electrical integrity (58%), and a visual check of the safety indices (92%). Most respondents perform only basic Doppler testing, featuring Doppler noise (50%) and functional checks (50%). Three respondents (25%) perform no Doppler testing. Colour is the most popular mode for Doppler testing (75%), followed by spectral (50%), then power (33%).

Discussion - The Doppler and safety tests which are performed by most responders do not require specialised equipment. The cost and diminished mobility that comes with a requiring a wide range of equipment are likely the largest barriers to more extensive testing being performed.

Conclusion - With the exception of testing dead zone, the majority of respondents performed the most extensive testing they could using only a tissue-equivalent test object.

A valuable follow-up study would be to audit departments which performs many of the IPEM 102 tests to determine which tests are most likely to uniquely identify faults.

Key references

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Acoustic Power Measurement of Cylindrical Transducers

David Bell

Background

The use of Radiation Force Balances (RFB) for acoustic power measurement of planar transducers in the medical frequency range is a well-established technology. This is commonly carried out in a top-down configuration using a commercial mass balance, with the target either placed on the balance pan or suspended underneath it. The change in apparent mass of the target in response to the acoustic power being turned on or off is proportional to the radiation force acting downwards on the target. There is a well-defined theoretical relationship between apparent mass, speed of sound in water and acceleration due to gravity for an ideal absorbing target. The relationship between apparent mass and transmitted power is only valid for plane waves emitted from an unfocussed transducer pointing vertically downwards. There are standard corrections to measured power values to allow for finite apertures, focused beams and attenuation in the water path. There was a requirement to measure the acoustic power from a 6 MHz cylindrical transducer using a standard RFB, including an assessment of the uniformity of transmitted power as a function of angle.

Methods.

Phase 1 - Restricting the angular range of transmission with a series of apertures and rotating the transducer to give the dominant propagation direction as vertically downwards. Apertures of different sizes were constructed to allow the measured total power to be determined as a function of different beam spread angles. Rotation was carried out by hand, with the RFB set up over an acoustic measurement tank – to give plenty of space for mounting and rotation.

Phase 2 - Evaluation and construction of conical reflectors, to allow all the ultrasonic energy to be directed vertically downwards. Both the geometric design and the material used for construction of the reflectors were comprehensively assessed. This was necessary to demonstrate that a high proportion of the transmitted energy was directed vertically downwards to the absorbing target.

Phase 3 - Application of the above techniques for the assessment of a commercially-produced unit for regulatory purposes.

For phase 1 and phase 2, the cylindrical transducer was assessed in isolation. For phase 3, the transducer was part of a catheter-based system with an integral cable and wire cage surrounding the transducer.

Results and Discussion.

Phase 1 – significant non-uniformity of transmitted power with angle was observed. Signal stability was an issue, due largely to working with a large volume of water.

Phase 2 – once the optimum material and geometry had been identified, consistent power measurements were obtained.

Phase 3 – working with the commercial device caused some difficulties in mounting and having adequate space within the RFB housing. These were largely overcome with the development of a suitable fixture, allowing most of the energy to be directed vertically downwards and for the main axis of the transducer to be aligned to the vertical axis. This is important as only the vertical component of the radiation force will be detected by the RFB.

Conclusion.

The use of apertures of variable size and manual rotation has permitted the investigation of non-uniformities in transmitted power. Development of conical reflectors to direct radial energy downwards to an RFB target has facilitated the measurement of acoustic power.

Key Words.

Transducer, acoustic power, reflector, radiation force balance

Is Monthly Ultrasound Quality Assurance Enough?

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Background. Previous studies have shown faulty ultrasound equipment can remain in clinical use[2,3], and a recent snapshot survey has reported probe fault rates up to 37%[1]. At STH, in-air reverberation ultrasound QA is performed monthly following national guidance[4]. Then, potentially faulty probes are confirmed with phantom testing. We have audited our QA programme over the previous six years and the results on probe failure and possible clinical consequences are presented.

Method. Probe failure data was compiled from monthly QA reports (spanning 2016 – 2022). The length of time the probe remained in service following the failure was obtained from the local equipment database. Clinical images for a subset of failed probes were reviewed for possible artefacts relating to the probe failure. If present, the date of an initial artefact appearance in clinical images were noted and scaled to infer the proportion of likely affected images. The effect on diagnosis was also reviewed in conjunction with a sonographer.

Results. There were 92 instances of transducer failure out of a total pool of 212 probes. The most common failure was attributed to crystal drop out (CDO).

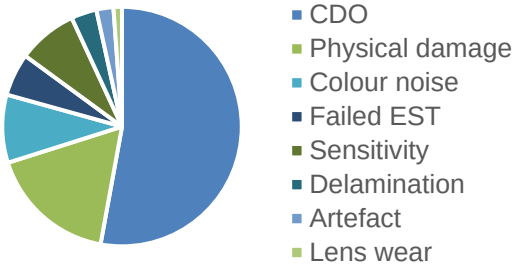

Figure 1: Total transducer failures, split by failure type.

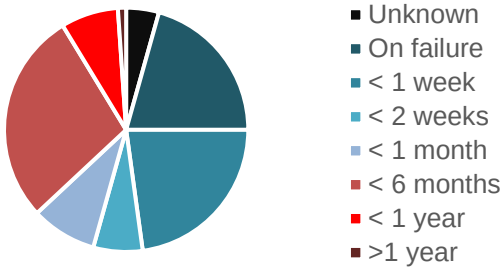

Figure 2: The length of time the transducers were left in service, following a failure.

Approximately 70% of failures were visible in a clinical image up to 7 days prior to the QA. The other 30% arose up to six months beforehand. Assuming 5 scans per day are using the failed probes, an average of 5% of clinical scans may have been affected with a clinical artefact.

Discussion. Around two-thirds of all probe failures were attributed to CDO or physical damage (Fig 1), both of which are likely to arise in a busy teaching hospital with multiple users. Most failed probes are removed from service in a timely fashion before the following QA. Yet, around one third of the failed probes were left in service for more than one month (Fig 2) - largely due to clinical approval. This is partially justified, as some failures did not manifest clinically until a later date (if at all) or are masked by image processing. However, the subset of the image data reviewed implied an average of 200 examinations may have indicated an artefact on clinical images. Thus, changes to current practice may be required.

Conclusion. Performing monthly QA allows identification of most faults with the potential of reducing clinical impact. However, our experience indicates more frequent QA testing would be beneficial. Results also suggest improved communication between Clinical Scientists and Sonographers is required to identify faults that may not be obvious from the monthly in-air images. Moving forward, we are planning to set-up regular meetings between Medical Physics and Lead Sonographers to communicate issues and agree upon probe performance together.

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Comparison of three Ultrasound Systems used in LDR Brachytherapy

Authors: Chris Mcleod[1], Scott Inglis[1], Paul Drewell[2], Chris Wood[2], William Keough[2]
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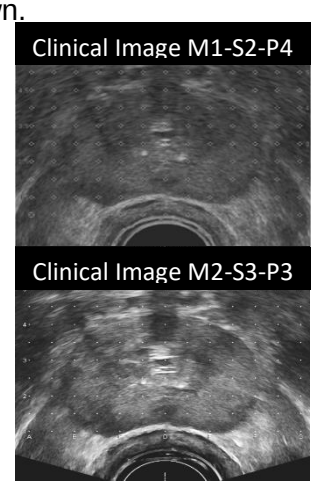
Background: Edinburgh Cancer Centre (ECC) provides a National LDR Prostate Brachytherapy service in Scotland with 60% of our patients residing outside NHS Lothian (NHSL). The service has used scanner model S1 and probe model P1 from manufacturer M1 for 9 years. In 2019 a second scanner model (S2) and probe P2 from M1 was procured. Clinical scanning started in early 2020 due to driver software for P2 yet to be developed. Acceptance of scanner S2 was then hampered due to sub optimal imaging. The clinical team returned to using S1. Medical Physics provides scientific and technical ultrasound support including the development of the Edinburgh Pipe Phantom (EPP) to assess performance [1,2]. As part of a NHSL replacement programme to replace S1, Medical Physics evaluated scanner (S3) and probe (P3) from manufacturer M2 and evaluated M1's new firmware for scanner S2, & probe P2 and a new probe design (P4).

Methods: The EPP was used with three scanners and four probes types (multiple probes of model P2 were tested) to determine the Depth of Field (Lr) and Characteristic Resolution (Dr) measurements. Measurements on the EPP were obtained using a rig designed to hold the probes. In addition the clinical team assessed all probe/scanner combinations, example of clinical images from the same patient using scanners S2 with P4 and S3 with P3 are shown.

Results: Results of the pipe phantom measurements and patient images:

OEM	Scanner	Probe	Date of test	R	Lr (mm)	Dr (mm)	Comments
M1	**S1**	**P1**	07/12/2020	49	71	1.45	Original kit
M1	**S2**	**P2 (a)**	07/12/2020	50	77	1.55	Issues reported
		P2 (b)	11/02/2021	51	78	1.53	Loan probe
		P2 (c)	04/10/2022	40	62	1.57	New software
		P4	04/10/2022	35	56	1.59	New software
M2	**S3**	**P3**	10/10/2022	53	60	1.13	2022 Procurement



Discussion: The results of the pipe phantom measurements indicate significantly better resolution with the scanner S3 when compared with scanner S1 and S2. The depth of penetration for the S3 is less than the S1, however, for prostate imaging we typically never exceed 5.5 cm of depth. The upgraded software on the S2 has poorer resolution and depth of penetration than both the S1 and S3. The pipe phantom measurements support the clinical observations to discontinue clinical use of the S2 with plans to replace it with a second scanner S3 as has been done with scanner S1.

Conclusion: Despite development of new driver software for scanner/probe combination S2-P2, clinical imaging was noted qualitatively to be sub-optimal. EPP testing of S2-P2 demonstrated that image quality was quantitatively poorer than for the system (S1-P1) it was intended to replace, despite being a newer system from the same manufacturer. EPP evaluation of a third system (S3-P3) from another manufacturer demonstrated significantly improved resolution, combined with adequate penetration and this has subsequently been purchased and put into use. Further, this demonstrates the utility of EPP testing as part of scanner evaluation and a robust procurement process.

Key references. In alphabetical order, numbered.*

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Title of Study Investigating the relationship between ultrasound sensitivity loss and image quality

Nick Dudley[1], Daniel Wyatt[1], Nick Gibson[2]

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[2]Nottingham University Hospitals NHS Trust

Background & aims: A key element of ultrasound quality assurance (QA) programmes is the measurement of sensitivity. User QA includes proxy measures designed to show that sensitivity may have changed. The traditional gold standard for sensitivity measurement is low contrast penetration (LCP) in a tissue mimicking test object (TMTO). Professional bodies and associations have recommended thresholds for action, e.g. IPEM Report 102 recommends a loss of 5% of 5 mm, whichever is greater. There is no evidence to support these thresholds. The aim of this project was to determine the impact on other measures of image quality of a loss of sensitivity.

Methods: TMTO images were collected from a range of probes using standard clinical settings. Output was incrementally reduced to simulate a loss of sensitivity; gain was increased to maintain image brightness, either through the use of automatic gain or manually. Images were analysed using the Nottingham QA software to determine LCP, resolution and contrast performance.

Results: At the time of writing 7 probes have been tested. A 5% loss of LCP occurred at output reductions of -0.5 dB to -4 dB, varying between probe types and manufacturers. Key findings with reduced output were an apparent improvement in resolution; a loss of contrast and visibility of low contrast (-6 dB) grey-scale targets (10% contrast loss at -0.5 dB to -2.2 dB); an increase in contrast of high backscatter targets; a reduction in visibility of anechoic targets, generally as LCP becomes the limiting factor but at a reduced output of -1 dB for the phased array.

Discussion: Resolution and high backscatter targets are not useful in determining the clinical significance of sensitivity loss. For linear and curvilinear transducers the limiting factor for visibility of small anechoic targets is reduction in LCP. Low negative contrast targets show reduced contrast as output is reduced. Image quality of the phased array in this study was most sensitive to reductions in output.

Keywords: Ultrasound; Quality Assurance; Sensitivity; Image Quality

Declaration of interest: Multi-Medix Ltd is a specialist provider of Ultrasound QA services

A computer aided assessment of ultrasound shear wave elastography imaging

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Background

Shear Wave Elastography (SWE) imaging is a quantitative technique, capable of measuring the stiffness of tissue. The Young's modulus (YM) is superimposed onto an ultrasound image using a 2D colour map. Typically scanner capabilities are limited to the assessment of small regions of interest (ROI) defined by the operator to quantify the YM pixel values within circular shaped ROIs. The aim of this study was first to develop a versatile image processing software to analyse the colour map pixel data and second to use our software for the computer aided assessment of elastography image performance.

Methods

We used our Leicester- St Thomas' Elastography Pipe (L-STEP) phantom [1] to acquire longitudinal images of 6 pipes of various diameters (6,5 to 1 mm diameters). SWE images were acquired using the linear probes from scanners from 6 different manufacturers. The probe, scanner, preset and standard settings were recorded for each acquisition. Images were first evaluated subjectively by eye to assess YM values in the pipes. Measurements were taken at 1cm depth increments until stiffness values were not registered and/ or not discernible from noise. MATLAB software was then used to correlate the RGB pixel values to the corresponding stiffness measurement, and take the same measurement. The mean YM and standard deviation of the values were recorded. Currently, only opaque elastographic images can give accurate values, which limits the evaluation on some manufactures.

Results

Computer aided assessment scaled well with subjective assessment and comparison helped validate our software. There was a variance in stiffness measurements across different ultrasound manufacturers. There is also an indication that both the size and depth of the pipe will affect the measured stiffness value.

Conclusion

We have developed an image processing software for the computer aided analysis of elastography images that is more versatile than analysis options available on scanners. YM line profiles and ROIs of any size, shape and orientation can be defined for assessment of YM. The software is suitable for use with our L-STEP phantom, or any opaque elastography image to help assess performance capabilities of scanners.

Key Words*: Ultrasound elastography, shear wave elastography, phantom, test object, image analysis*

References

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