Learning objectives

The description of the Quantitative Elastography QElaXto (Esaote S.p.A., Genova, Italy) point Shear Wave Elastography (pSWE) technology and the illustration of the technical and practical aspects for a correct procedure of tissue stiffness quantification of the liver.
Background

pSWE delivers a quantitative measure of tissue stiffness (expressed in Shear Wave propagation velocity or deduced Young Modulus in KPa) for a small tissue sample. pSWE is based on a perturbation and a reading phase. Non-invasive methods such as pSWE can now be used instead of liver biopsy in patients with chronic hepatitis C, to assess liver disease severity (fibrosis) before therapy at a safe level of predictability.

What pSWE is about
Point Shear Wave Elastography (pSWE) technology is characterized by the generation of a shear wave originated by an Ultrasound focused beam, which creates a localized perturbation in a small region around a focused shock point. This perturbative phase is followed by a reading phase in a Region of Interest (ROI) providing a quantitative estimate of liver stiffness inside the ROI. The ROI is therefore the graphical representation of the considered reading area where the shear wave propagates and where the quantitative analysis is performed.

Tissue Elasticity Evaluation
Tissue has different mechanical properties and elasticity is one of these components. Elasticity is the property of a material or a tissue to deform under a given stress (for example, due to external forces applied) and then to restore to its original shape after distortion. Evaluation procedure of elasticity properties involves deformation of a tissue in response to the application of an external load: practically, two Ultrasound Elastography main modalities are today available: Strain Elastography (Qualitative) and Shear Wave Elastography (Quantitative).

Liver Elasticity Evaluation
The European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) indicated that today noninvasive methods can be used instead of liver biopsy in patients with chronic hepatitis C to assess liver disease severity (fibrosis) before therapy at a safe level of predictability.

pSWE Advantages
Non-invasive solution to evaluate liver fibrosis.
An alternative to gold standard (Liver Biopsy).
Ultrasound guided-imaging technique.
Complementary to a B-mode liver evaluation.
Definitely less expensive than MRI Elastography (MRE).
QElaXto - Esaote pSWE - Intended use
Liver stiffness is demonstrated to be suitably mapped to liver fibrosis stages (Metavir classification).
The scope of QElaXto is the measurement of the Liver Fibrosis levels, which are related, according to Metavir classification, to a level of stiffness up to 15-20KPa (limit F4 over which the Fibrosis becomes Cirrhosis, irreversible and not curable).
Metavir classification:
F0= no fibrosis,
F1= minimal fibrosis,
F2= fibrosis has occurred and spread inside the areas of the liver including blood vessels,
F3= fibrosis is spreading and connecting to other liver areas that contain fibrosis.

What is usually measured are the F0- F2 Liver Fibrosis levels, which are reversible with proper therapies. As a general reference table (differences can be present among Clinical Centers), the following stiffness ranges are related to corresponding Liver Fibrosis Metavir classifications:
F0-F1 (< 7 kPa),
F2 (7-9.5 kPa),
F3 (9.5-12 kPa),
F4 (> 12 kPa).
Findings and procedure details

Practical steps and technical procedure to achieve proper QElaXto tissue stiffness quantification of the liver are described. Proper insights are given regarding the latest advancements in terms of technology and workflow optimization. Some technical tools for a real-time feedback of the measurement quality assessment, as well as some optimized workflow solutions, are described. Available measurements and indexes are considered as well as tips and tricks for their correct assessment.

QElaXto - How it works
QElaXto delivers a quantitative measure of liver stiffness (expressed in Shear Wave propagation velocity or deduced Young Modulus in KPa) for a small tissue sample. QElaXto is based on a perturbation and a reading phase. The system has a set value of measurement rejection, which skips the values outside the accepted range.

The tool was tested on MyLabTwice (Esaote S.p.A., Genova, Italy) with CA541 appleprobe iQ Convex Transducer.

QElaXto is one-dimensional with small ROI and some special features to facilitate the data analysis:

- Indication of shock and gate locations: useful to drive the operator to select suitable measurement areas:
- 3D eWave Shear Wave Quality Graph for immediate feedback about measurement quality: 3D histogram qualitative display of the propagation of the perturbation Space-Time-Displacement (blue: low, red: high):
- Automatic reliability tool of performed measurements based on statistical analysis of acquired RF signals: Accept or Skip measurement.

Among the statistical data offered by QElaXto, the following measures and indexes are present, in order to improve confidence of the correct data acquisition:

- MED: Median

In statistics and probability theory, the median is the number separating the higher half of a data sample, a population, or a probability distribution, from the lower half, i.e. the second quartile defined as Q2.

- IQR: Interquartile range

The interquartile range, also called the mid spread or middle fifty, is a measure of statistical dispersion, being equal to the difference between the upper and lower quartiles, IQR = Q3# Q1.

- Measurements available in m/s and KPa (possible selection in Real-time).
User Interface optimized for productivity and fully customizable:
• Ergonomics and Productivity workflow: palm distance controls.
• AutoUnFreeze after the cooling cycle.
• Audio feedback when cooling ends.
• Info Window when measurement protocol completed.
• ROI Depth indication.
• Quick Cooling pause (2-3 seconds in average) for improved productivity and exam speed up.
• Cooling indication (SnowFlake) directly on the measurement site for "no look around" feedback.
• Automatic save of image at each measure.
• Freedom of measurement selection/delete and real time update of related statistics.
• Dedicated Report and Worksheet.

QElaXto - Tips & Tricks
In order to correctly perform the pSWE measurement, the following steps and tips are suggested:

1. Put the right arm of the patient behind his/her head in order to maximize the intercostal space.

2. The acquisition has to be performed with the patient in fasting conditions, otherwise the liver stiffness measure would be altered by the digestion process.

3. QElaXto Esaote pSWE technology generates shear waves inside the liver by using radiation force from a focused ultrasound beam.

4. The shear waves are generated near the region of interest in the liver parenchyma. The perturbation area is indicated with a point (see 1) positioned close to the ROI (Region Of Interest, see 2), where the Shear Wave velocity is measured.

5. The shear wave velocity is displayed in meters per second or valorized in kilopascals through the conversion to equivalent Young modulus value [Def.: Young's modulus, also known as the tensile modulus or elastic modulus, is a measure of the stiffness of an elastic material and is a quantity used to characterize materials. Young's modulus, E, can be calculated by dividing the tensile stress by the extensional strain in the elastic (initial, linear) portion of the stress-strain curve].

To transform the velocity in kilopascal, the assumption of isotropy is supposed together with unitary density (#=1 g/mm^3, like water), setting YM = 3##
6. Right intercostal access has to be used, with the patient in the dorsal decubitus position, examining the right lobe of the liver (VI/VII segments) by using the Convex array appleprobe CA541.

7. As general guideline, QElaXto measurements are performed at about 1 cm below the Glisson capsule to avoid reverberation artifacts. Typical depths are around 3 cm and anyway less than 5 cm. Moreover, in function of the patient anatomy, great attention has to be taken to setup the measurement ROI in homogenous areas free of vessels and not significantly affected from uncontrolled movements induced by heart beatings; as general guideline, zoom properly the B mode image acting on Depth keyboard control, setting image maximum depth equal to 8 cm, in order to properly position the ROI for QElaXto measurement.

8. The coupling between probe and liver has to be complete (the whole echo image has to be properly visible) - a correct amount of gel has to be used. Dark areas of the echo image have to be avoided.

9. The operator elbow should rest on the patient's bed (or any other stable support) in order to be firm during pSWE measurement acquisition.

10. A correct pressure has to be applied, in order to be stable and to be properly coupled with the skin over the liver - the pressure doesn't have to be excessive in order not to compress the liver.

11. No respiration during a measure (the patient should be asked to stop breathing just for a moment in neutral respiratory phase; in inspiration the liver is compressed by lungs).

12. It has to be checked not only the point of measurement, but also the adjacent planes to avoid vessel and bile ducts. A slight probe transverse movement would be needed in order to have wider view (even if the ROI is bi-dimensionally represented, the measurement performed is physically three-dimensional).

13. The Shear Wave graphic representation gives an interesting feedback of how good is the measurement.

14. According to Metavir classification for liver fibrosis staging as function of undergoing pathology and stiffness, the practical range of liver stiffness is up to 25 KPa. A proper heuristic based on statistical assessment of collected data is used to reject...
measurements which are not considered reliable. The user can anyway decide to accept and/or reject every measure.

15. After each measurement, a cooling phase of few seconds is needed and automatically managed by the system (a proper "cooling icon" is shown close to the QElaXto ROI).

16. The SWE measurement has an intrinsic variability both operator and system dependent.
Images for this section:

**Fig. 1:** MyLabTwice system with CA541 appleprobe iQ Convex Transducer

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Fig. 2: QElaXto pSWE shock and gate indication

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Fig. 3: 3D eWave three-dimensional representation of the generated Shear Wave in terms of Displacement, Space and Time
**Fig. 4:** Automatic reliability tool of performed measurements, based on statistical analysis of acquired RF signals

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Fig. 5: QElaxto pSWE acquisition example showing related measurements and indexes

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Fig. 6: QElaXto report

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**Fig. 7:** QElaXto pSWE acquisition detail of point of perturbation (1) and region of measurement (2)

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**Fig. 8:** Young modulus formula

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**Fig. 9:** QElaxto pSWE acquisition in terms of proper probe and patient’s positioning

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**Fig. 10:** QElaxto pSWE acquisition in terms of generated Shear Wave quality evaluation by 3D eWave

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**Fig. 11:** cooling icon close to the QElaXto ROI

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Conclusion

QElaxto pSWE is a feasible method for non-invasive assessment of liver fibrosis.

Knowledge of technical and practical aspects is crucial for the correct application of SWE and to perform proper measurements of the liver stiffness.

Optimized workflow and real-time feedback tools can be useful in terms of examination speed up and improved diagnostic confidence.
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References


