Acoustic streaming (Non-vascular application of colour Doppler) in differentiating complicated cyst and solid lesion in breast – a case study and review of literature

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Abstract:
Background: Complicated cysts in breast filled with internal echoes simulate solid lesion on B-mode sonography. Doppler technique can be used in such cases to differentiate cysts from solid lesions. On applying Doppler, high intensity pulses are used to induce acoustic steering in cyst fluid and this motion is detected using Doppler technique. Acoustic streaming cannot be generated in solid lesions and hence is indicative of a cyst.
Methodology: Complicated breast cysts with internal echoes seen on B-mode sonography, were prospectively evaluated for the presence of acoustic Streaming on applying colour Doppler.
Results: Acoustic streaming was detected in complicated cyst. Motion was clearly generated and detected on B-mode in the form of increased motion of internal echoes within the cyst away from transducer which were stationary on gray scale imaging and flow velocity was detected which was < 4 cm/ s.
Conclusion: This technique is especially useful in indeterminate lesions in breast in whom differentiating between solid and cystic lesions is difficult on gray scale Ultrasonography.

Introduction:
B-Mode Ultrasonography is an excellent modality in differentiating between cystic and solid lesions, especially when the cyst is anechoic with no internal echoes or septae or solid components. However, many a times the cyst is filled with multiple fine to medium level internal echoes and differentiating between cystic and solid lesions becomes difficult on gray scale imaging. The purpose of this case study is to evaluate utility of streaming detection for identifying fluid motion in cyst, thereby allowing indeterminate cyst to be differentiated from solid mass. Doppler technique can be used to differentiate such cysts from solid lesions. This technique can be applied in complicated cysts in breast, thyroid, haematocoele/pyocele, complicated ovarian cysts vs. endometrioma, sebaceous cyst, hematoma and abscess in soft tissues.

Case report:
A 35 yrs old female patient presented with lump in right breast in upper outer quadrant since 6 months. It was gradually increasing in size. No associate pain or fever was noted. Clinical examination showed firm well defined swelling in upper outer quadrant of right breast. USG examination showed well defined ovoid shaped lesion measuring approx. 3.3 X 1.8 cms. It was echo poor and filled with multiple medium level internal echoes.
significant vascularity or calcification noted. Other quadrants showed normal echo anatomy. On B-mode, it was difficult to differentiate between complicated cyst and solid lesion. On colour Doppler interrogation, multiple medium level internal echoes which were stationary on gray scale imaging within the lesion showed rapid movements within the lesion away from transducer. Flow velocity of 1 cm/sec was detected on spectral Doppler. Hence diagnosis of complicated cyst was given. Aspiration of cyst under USG guidance revealed turbid fluid.

**Discussion:**

Novel ultrasound technique called acoustic streaming using colour Doppler can be used for differentiating complicated cysts from solid lesions. High intensity pulses are used to induce acoustic streaming in cyst fluid, and this motion is detected using Doppler techniques. On applying Doppler, high intensity pulses are used to induce acoustic steering in cyst fluid and this motion is detected using Doppler technique. Acoustic streaming is defined as movement of particles within the cyst away from the transducer during gray scale and/or Colour Doppler imaging after the ultrasound probe had been held still for some time to ensure that the movement of particles was not caused by movement of probe or patient. [1]

The fluid motion is caused by the absorption of acoustic energy, which exerts a force on the fluid that causes it to flow in the direction of wave propagation, away from the transducer. Fluid velocities that reach a threshold are detected and displayed as acoustic streaming. The Doppler cursor is used to focus the acoustic energy in the centre of the cyst. Acoustic streaming cannot be generated in solid lesions, therefore, its detection would indicate a cyst. Induced flow velocities are usually less than 4 cm/sec. Acoustic streaming means bulk movement of fluid due to a sound field, caused by energy transfer from an ultrasound wave to a fluid. [2] Acoustic streaming is defined as movement of particulate material within fluid due to energy transfer when an ultrasound wave is directed at it. The transfer of energy occurs when the sound wave strikes reflecting and absorbing obstacles in the path and is related to attenuation. [1]

Acoustic streaming was first investigated by Rayleigh, who studied circulation of air observed in Kundt’s tubes. Eckart theoretically studied the acoustic streaming profiles generated by the uniform cylindrical ultrasound beam in an infinite circular tube. The beam has a much smaller width than the tube diameter. He considered linear Navier Stokes equations at the steady-state. Perelomova developed projecting method to study the effects of acoustic heating and acoustic streaming. Acoustic streaming induced by diagnostic B-scan transducers and scanned diagnostic arrays have been investigated both theoretically and experimentally. Diagnostic ultrasound transducer induced acoustic streaming velocities up to 15 cm/s. Streaming velocities inside blood vessels or other confined volumes are expected to be much lower. [3] Edwards et al were the first to examine acoustic streaming in the cyst fluid of adnexal masses. [4]

Movements of fluid particles are seen in the direction of the beam away from the transducer. Acoustic streaming velocity is determined by properties of the fluid (acoustic attenuation, viscosity, and sound velocity), applied intensity, sound frequency, transmit aperture size, and pressure amplitude.

Cyst size, its morphologic characteristics are documented with gray scale imaging. The cyst is brought as close as possible to the transducer with the use of a bimanual technique. Overall 2-dimensional gain needs to be increased to visualize the particles in some cysts.
Sonography is then applied to the cyst (either entire or part of cyst) to assess streaming of cyst particles. If there is movement of the particles within the cyst away from the transducer acoustic streaming is said to be present. This is double checked by turning off the colour Doppler mode, waiting for particle movements to cease, and then reapplying the colour box. After demonstrating acoustic streaming, a 2-mm pulsed Doppler sample volume is then placed within the distal portion of the cyst, to record streaming velocity. The cyst had velocity less than 2.0 cm/s. Streaming velocity is inversely proportional to fluid viscosity. It decreases with increasing fluid viscosity. Acoustic streaming velocity increases with increasing attenuation, increasing frequency, decreasing transmits aperture size, and increasing pressure amplitude and nonlinear enhancement. If frequency, intensity, and transmit aperture size remain constant, there is a stronger association between cyst content viscosity and acoustic streaming velocity and a weaker association between cyst size and acoustic streaming velocity. Hence estimations of the viscosity of ovarian cyst content may be possible in the clinical setting. Complicated cysts in breast contain low level internal echoes, lack posterior acoustic enhancement and have imperceptible walls. These simulate solid mass on B-mode ultrasound. A cyst with thick viscous fluid or haemorrhage within a cyst simulate solid lesion on B-mode ultrasound. Beam position within the lesion has an effect on acoustic streaming. If the beam is focused in the centre of the cyst as opposed to the periphery of the cyst, higher streaming velocities occur. Complicated cysts are cysts characterized by homogeneous low level internal echoes. They may have fluid-fluid or fluid-debris levels (BIRADS lesion classification). Complex masses are masses that contain both anechoic and echogenic components i.e. partly fluid filled and partly solid masses. These masses are managed more aggressively than complicated cysts because they have a 42% prevalence of malignancy. These lesions should undergo either core biopsy of the solid component or excisional biopsy of the entire lesion because the solid component is viewed with suspicion. Streaming detection is not recommended for evaluating complex masses because detection of cyst fluid would not alter the management of the solid component of the complex mass. Hence this technique is not recommended for irregular masses, those with ill-defined or spiculated margins, those that are taller than they are wide, or any lesion that has other features suggestive of malignancy. Biopsy would be recommended for such lesions to exclude malignancy, and streaming detection would have no role in evaluating these lesions. 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Figure-2
Application of colour Doppler showed movements of internal echoes away from transducer on real time(acoustic-streaming).

Figure-3
Pulse Doppler showing Streaming velocity of 1 cm/sec.

References