Ultrasound physics

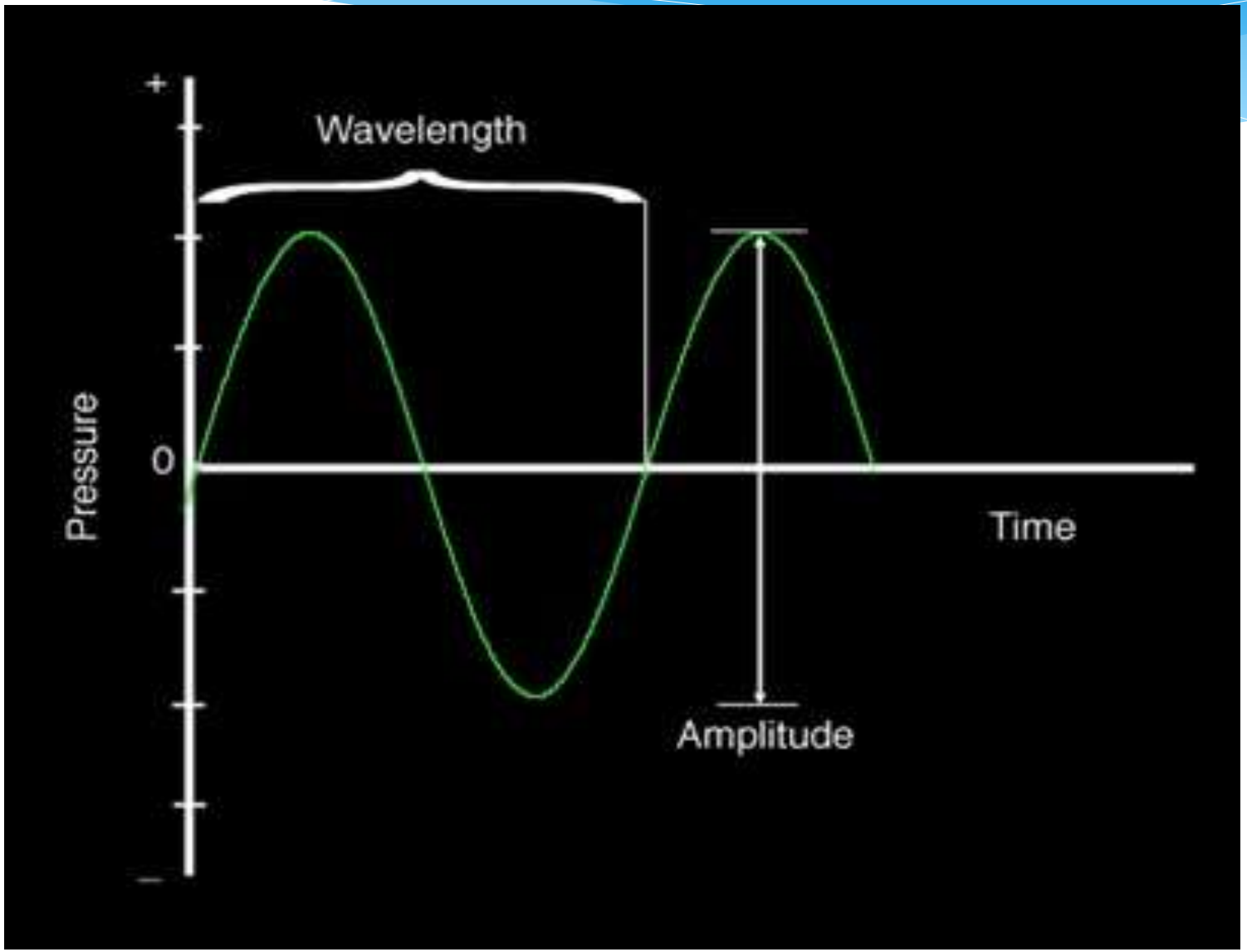
* **Sound is a pressure waves that travels in a medium in a longitudinal and straight fashion.**

* **When a sound travel through a medium, the molecules of the medium are alternatively squeezed and stretched forming zones of compression and rarefaction in the medium .**

The wavelength is the distance traveled during one cycle.

One cycle of the acoustic wave is composed of a complete positive and negative pressure change.

The frequency of the wave is measured in cycles per second or Hertz (cycles/s, Hz).


+
Wavelength
Pressure
0
Time
Amplitude
–

humans audible sound ranges between **20 Hz and 20,000 Hz (20 kHz).**

If the frequency is **less than 20Hz** it cannot be heard by human ear and is defined as **infrasound.**

If the frequency is **higher than 20 Khz** it cannot be heard by human ear and is defined as **ultrasound.**

Ultrasound

refers to any sound waves with frequencies greater than 20kHz.

Diagnostic ultrasound typically uses frequencies between **2and 20 million Hertz (MHz).**

The **speed of an acoustic wave** traveling through a specific medium is determined by the stiffness of that medium.

The greater the stiffness, the faster the wave will travel.

This means that sound waves travel faster in solids than liquids or gases.

How is ultrasound generated

Ultrasound waves are generated from tiny piezoelectric crystals packed within ultrasound transducer.
When an alternate current applied to these crystals ,they contract and expand at the same frequency at which the current change polarity and generate an ultrasound beam
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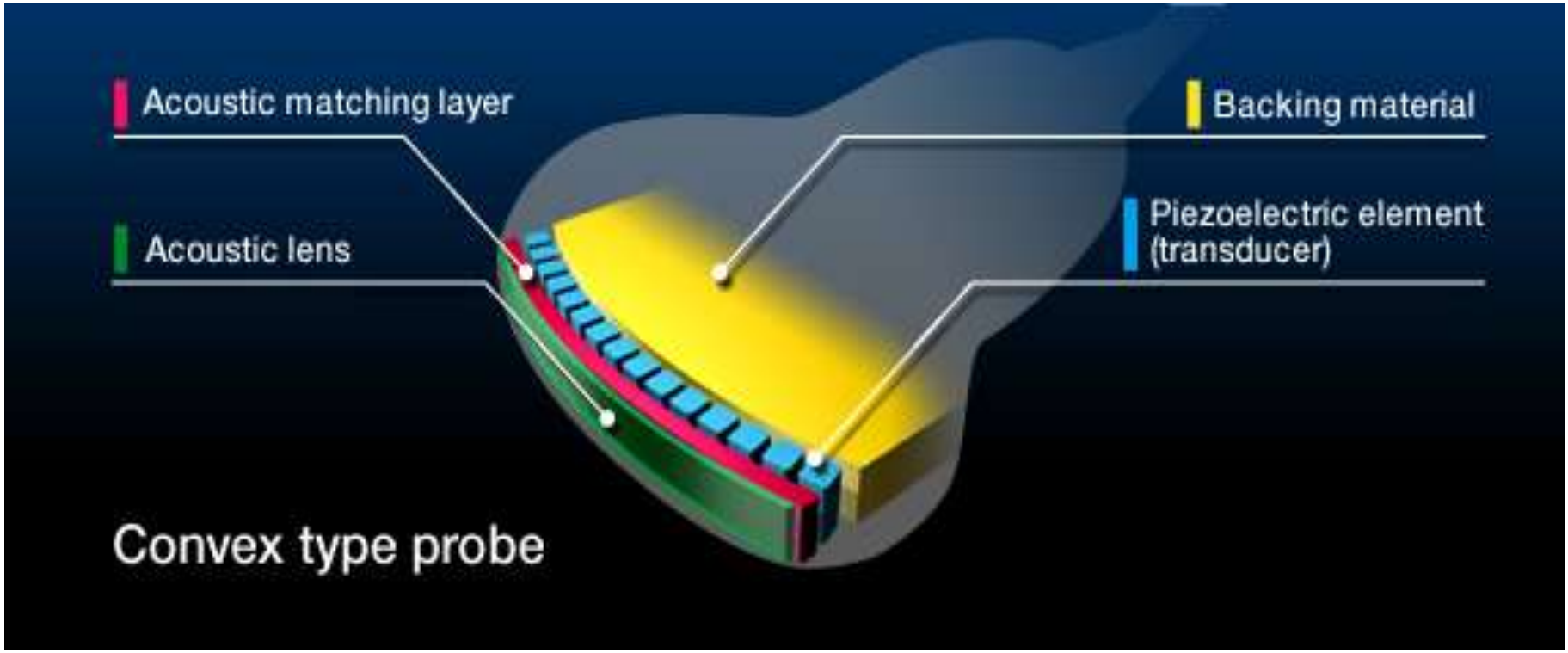
The piezoelectric crystals within the transducer transform electric energy into mechanical energy(ultrasound) and vice versa

The crystals are protected by rubber covering that help decrease the resistance to sound transmission from crystals to the body



The major sources of attenuation of sound waves in soft tissue are:

1-absorption (cause conversion of acoustic energy into heat).

2-reflection some of the waves bounce back towards the source as an echo .

3-refraction

If the two mediums have different "stiffness" the resulting change in propagation speeds will cause the wave to be "bent" from its original path

4-Scatter

occurs when ultrasound waves encounter a medium with a **heterogeneous surface** while most of the original wave continues to travel in its original path

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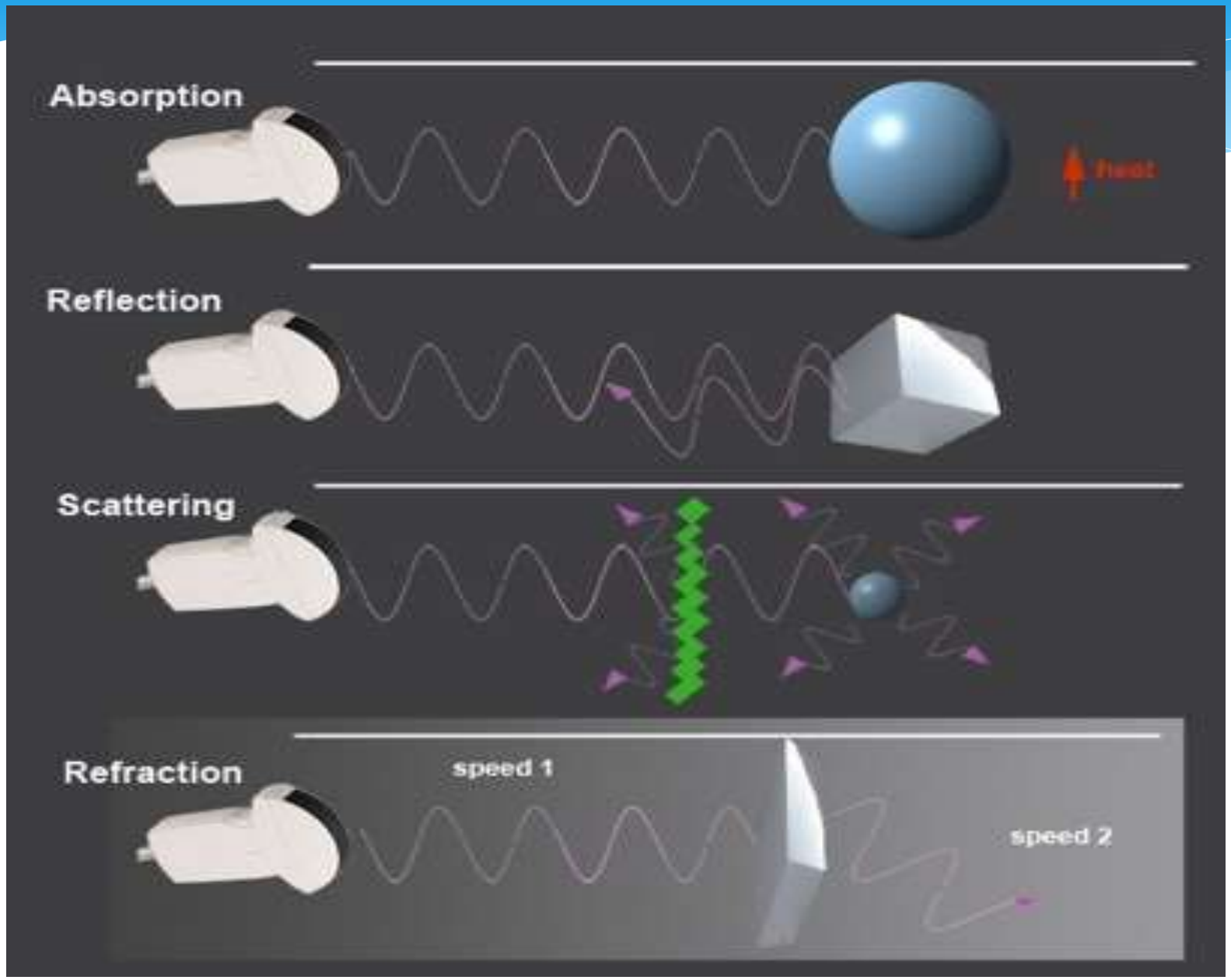
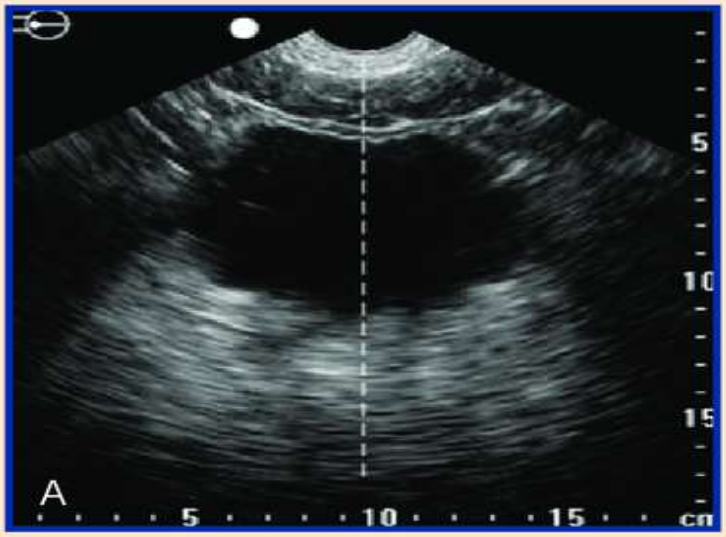
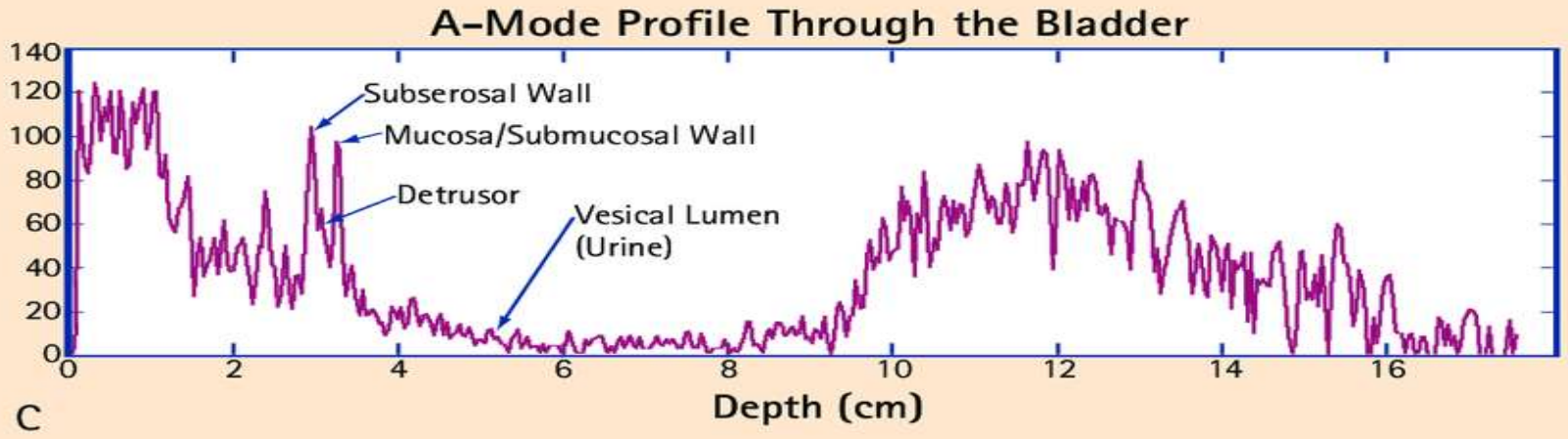

Absorption
heat
Reflection
Scattering
Refraction
speed 1
speed 2

Ultrasound modes

A-mode: A graphical spike in the amplitude of the ultrasound wave at the interface between two different tissues (*e.g.*, subcutaneous fat and muscle) is displayed during A-mode scan and the distance between the various structure can be measured. This pattern is not usually displayed .


A
5
10
15
cm


B
5
cm


A–Mode Profile Through the Bladder
140
120
100
80
60
40
20
0
Subserosal Wall
Mucosa/Submucosal Wall
Detrusor
Vesical Lumen
(Urine)
0
2
4
6
8
10
12
14
16
Depth (cm)
C

Ultrasound Modes

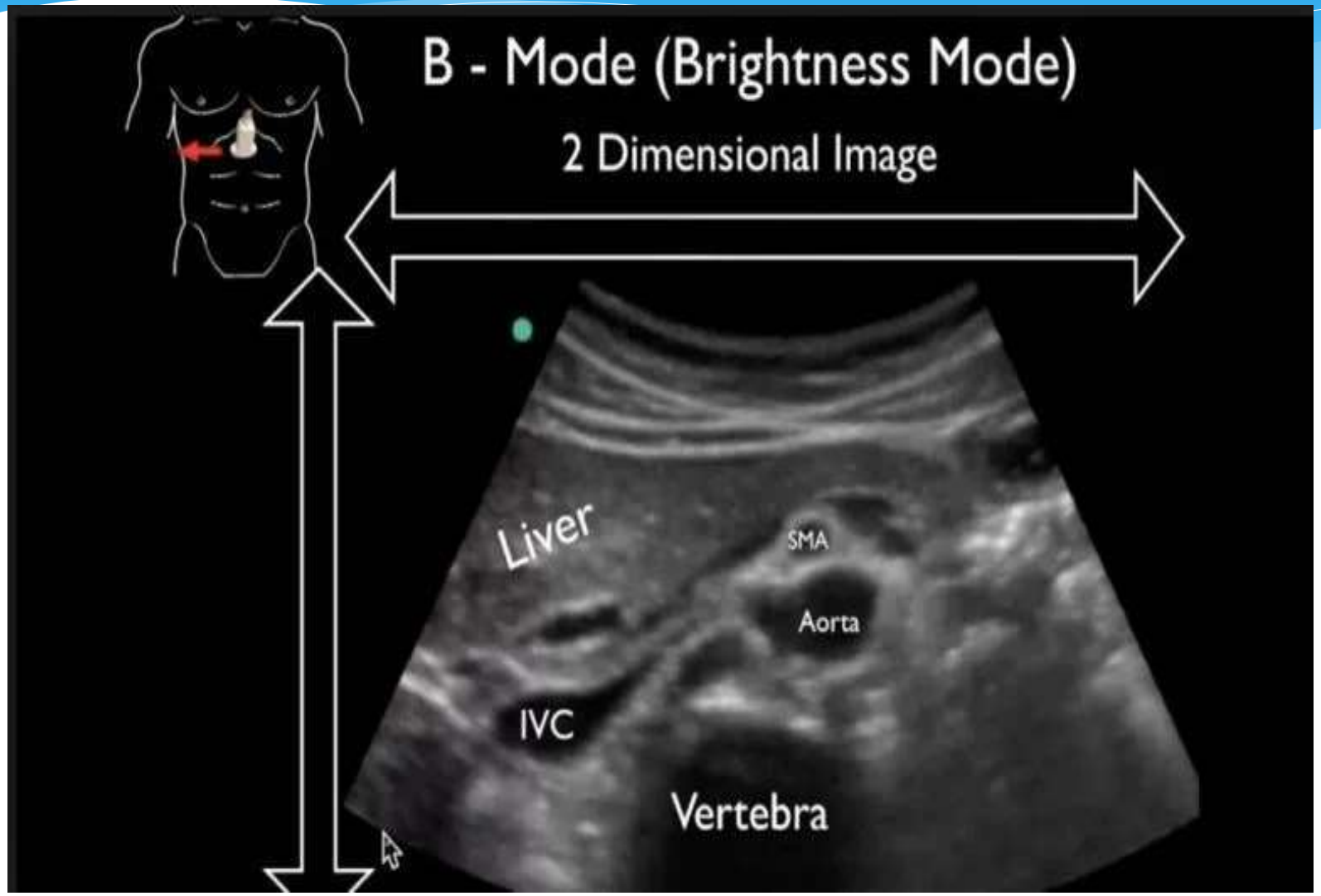
B-mode or 'brightness mode' provides structural information utilizing different shades of gray (or different 'brightness') in a two-dimensional image .

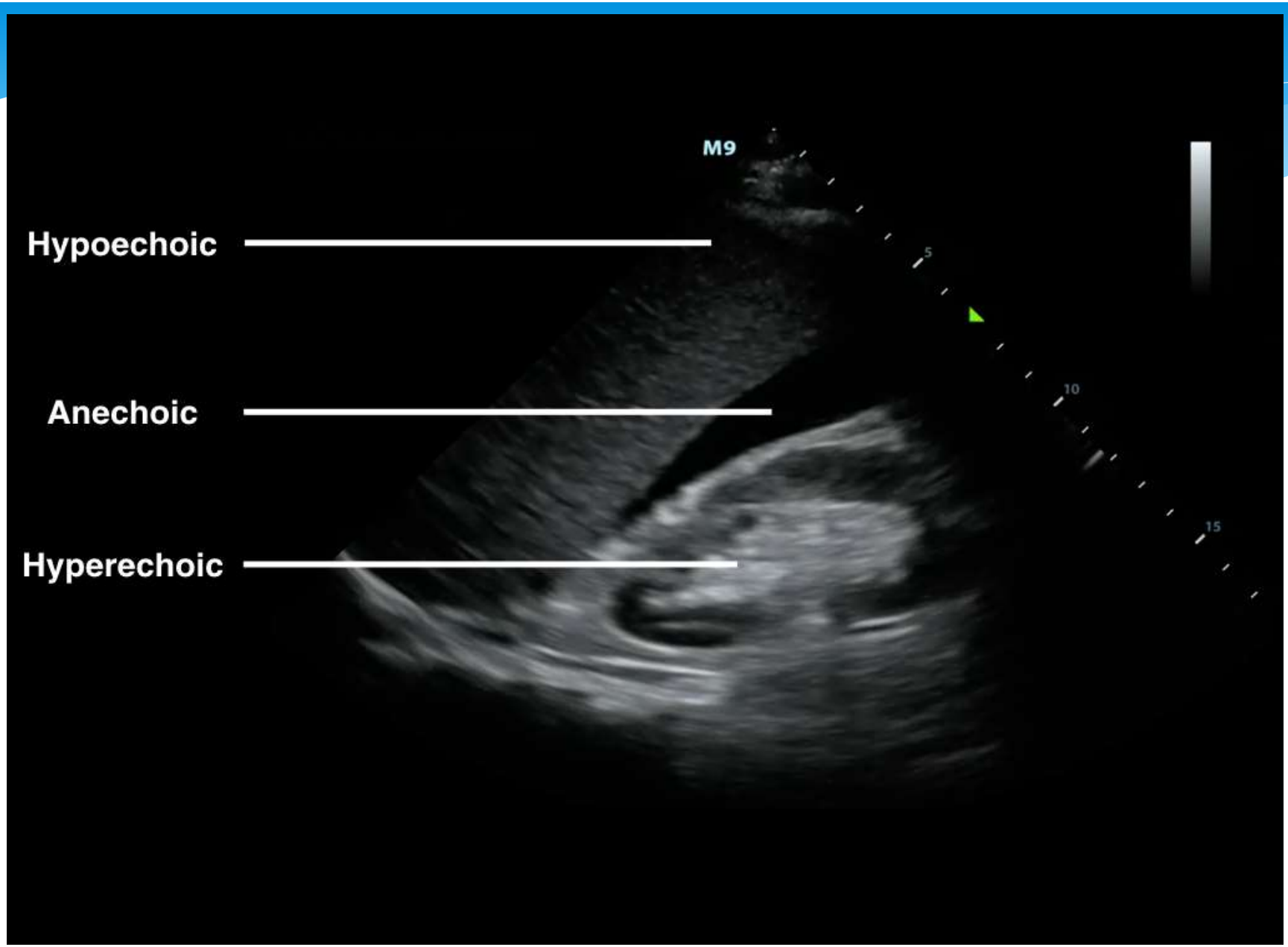
Anechoic/Echolucent – Complete or near absence of returning sound waves, area is black

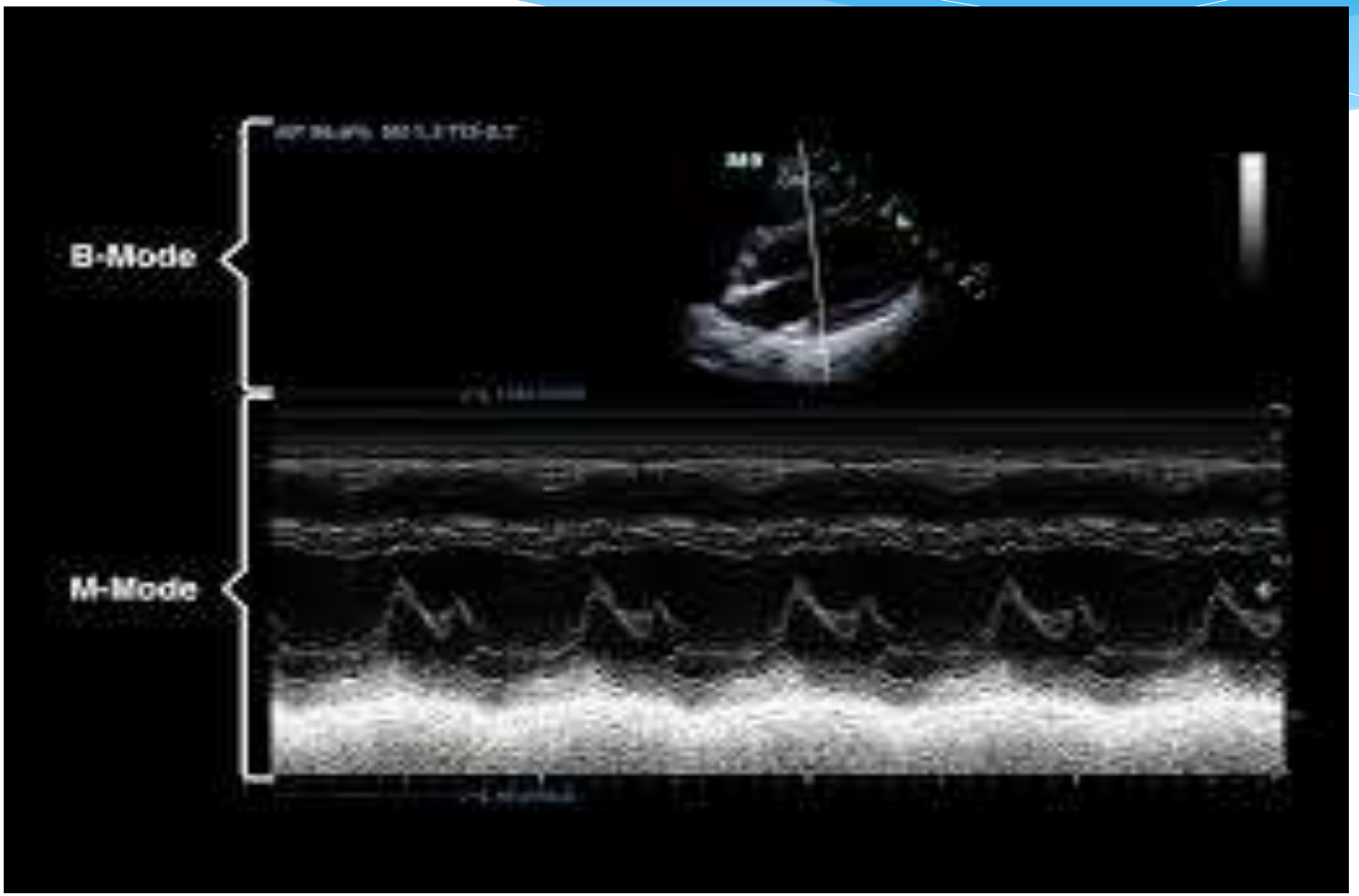
Hypoechoic - Structure has very few echoes and appears darker than surrounding tissue

Hyperechoic/Echogenic – Large amplitude of returning echoes appears brighter than surrounding tissue

M-mode (motion mode) captures returning echoes in only one line of the B-mode image displayed over time .
Movement of structures positioned in that line can now be visualized.


B - Mode (Brightness Mode)
2 Dimensional Image
Liver
SMA
Aorta
IVC
Vertebra


Hypoechoic
Anechoic
Hyperechoic
M9
5
10
15


B-Mode
M-Mode

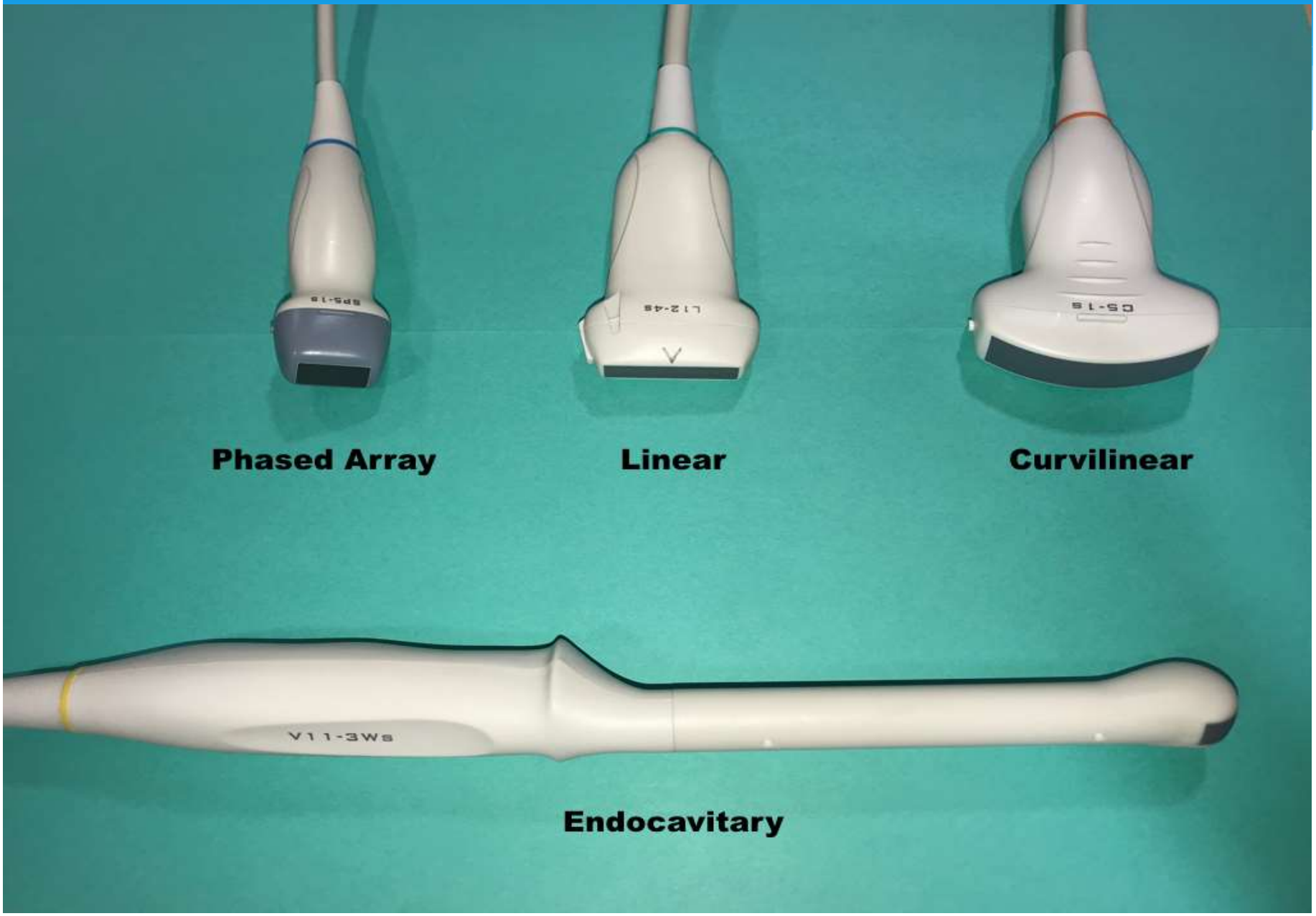
Probes

1-curvilinear Main utilization is transabdominal sonography

2-linear Main utilization is vascular sonography,and superficial soft tissue

3-phased array Main utilization is cardiac sonography, ideal for use between ribs

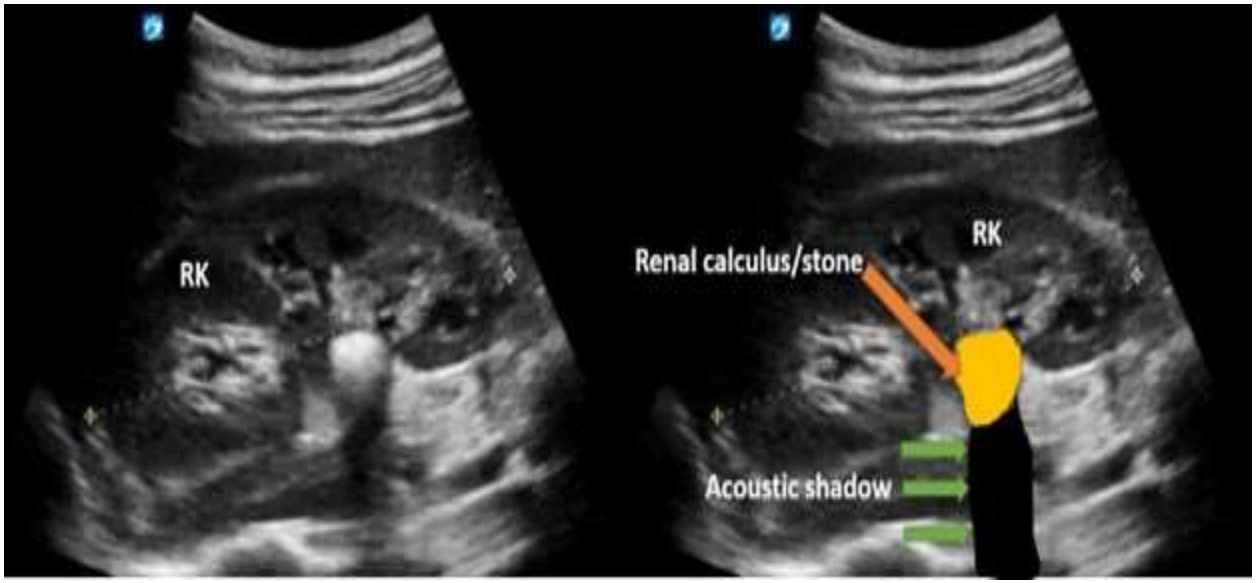
4-endocavitory main utilization is endovaginal


Phased Array
Linear
Curvilinear
V11-3Ws
Endocavitary

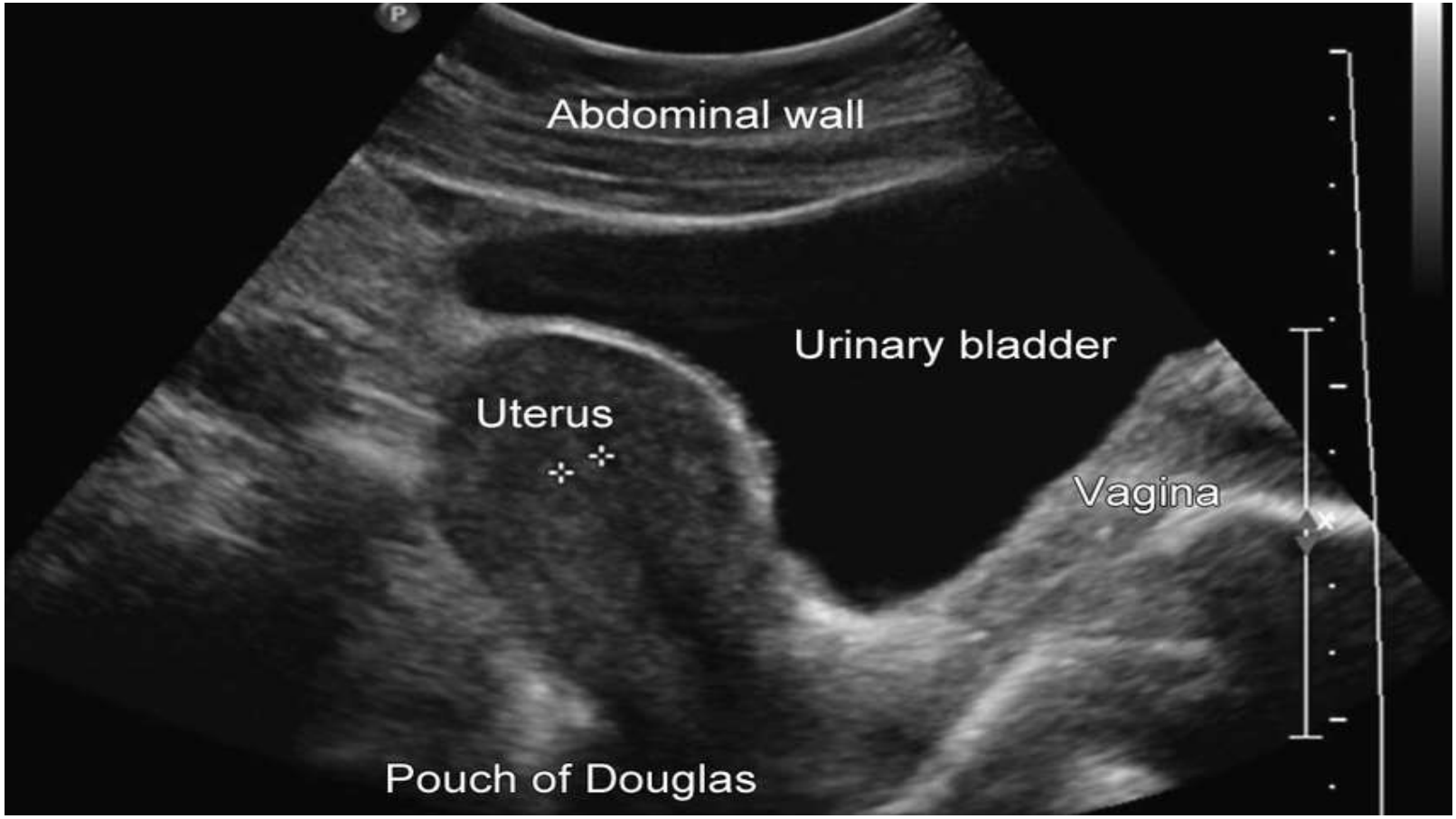
Ultrasound terms

1- Acoustic enhancement

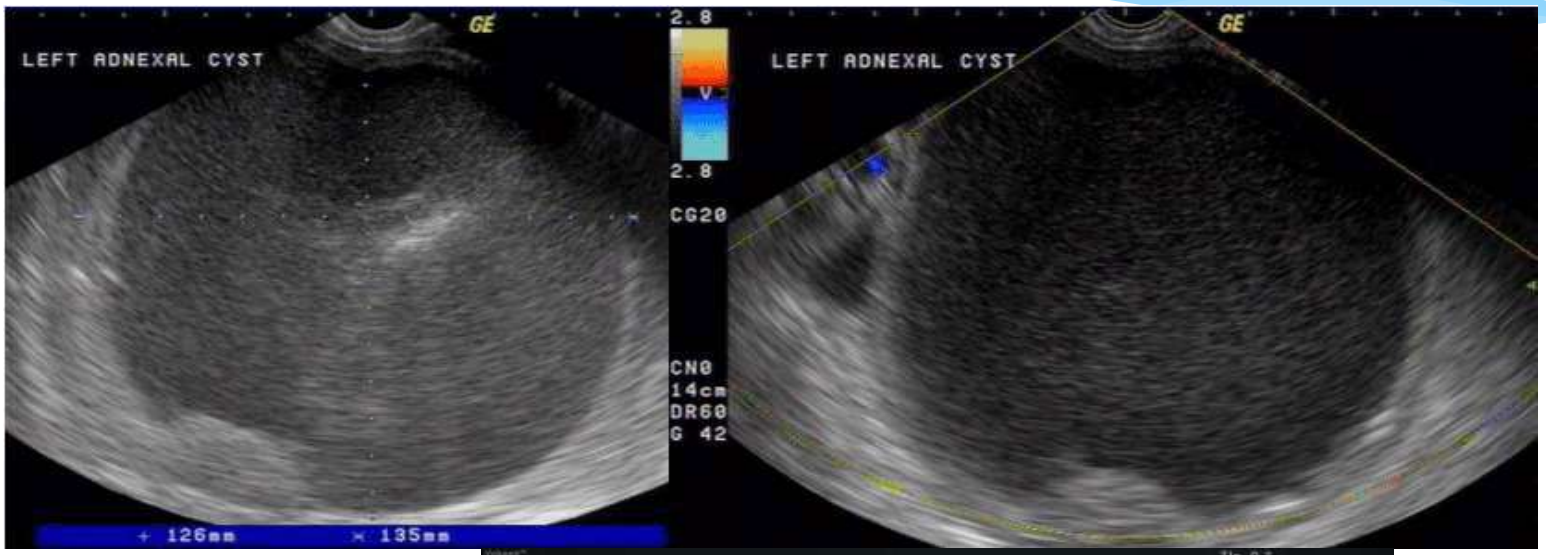
2-Acoustic shadowing



Acoustic window



Cyst and internal echoes



Thank you