

ULTRASOUNDS
and their
MEDICAL APPLICATIONS

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Outline

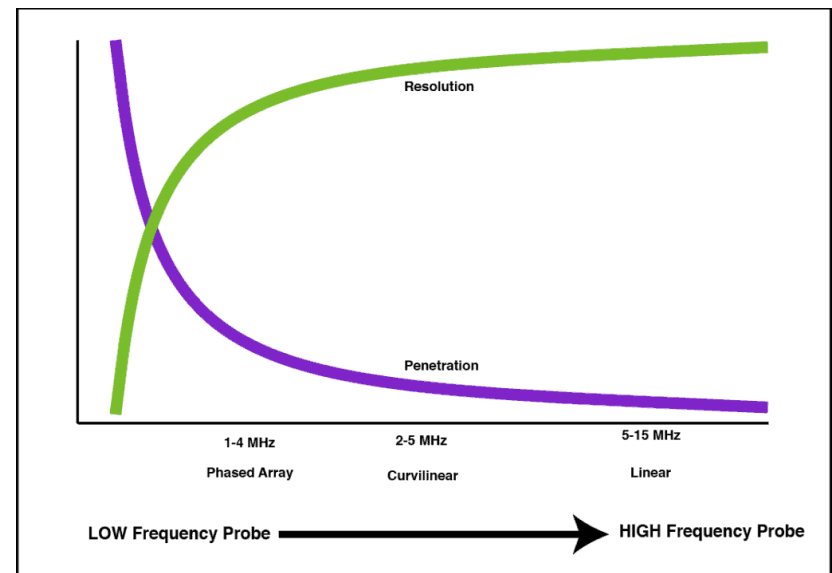
- Introduction
- Applications to medical diagnosis
- Therapeutic applications

Transducers in echography

Linear array curved array phase array
endocavitary array

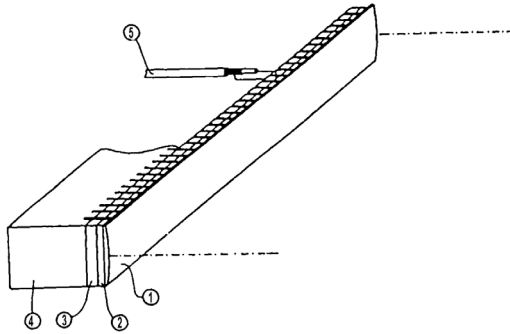


Frequency and penetration depth

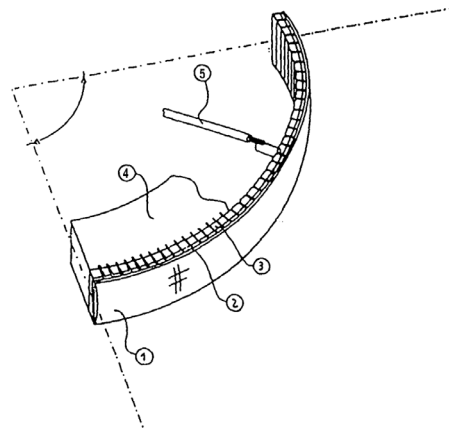


Echographic probe : typ. 128->256 transducers (arrays)

Rectangular array

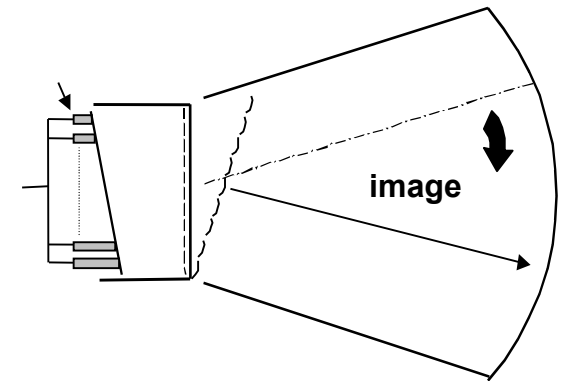


Curved array



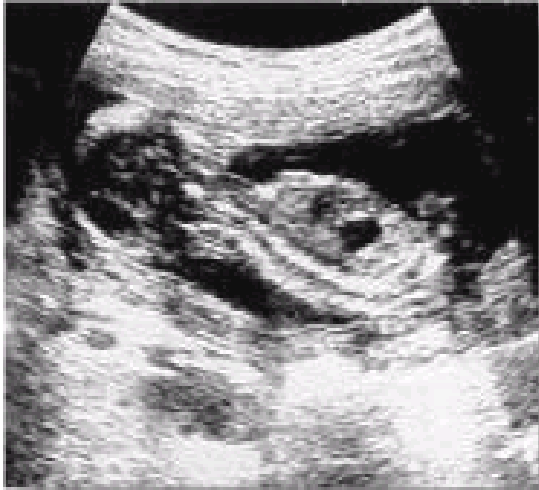
Sectorial image

« Phased array » : heart



- 1 acoustic lens
- 2 matching layer
- 3 piezo-electric ceramic
- 4 backing
- 5 coaxial line

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Toward 3D imaging and portable systems



Voluson SWIFT women's health ultrasound.



WED-180 Portable Ultrasound System with Linear HL Probe, 7.5 Mhz



<https://eu.clarius.com>

Cost : from few 100 k€ to.....1-5 k€!!

Conventional applications

- Gynecology - obstetrics (fetus)
- Abdomen (kidney, liver ...)
- Heart
- Vascular (arteries)
- Thyroid
- Muscles and tendons
- Eye etc ..

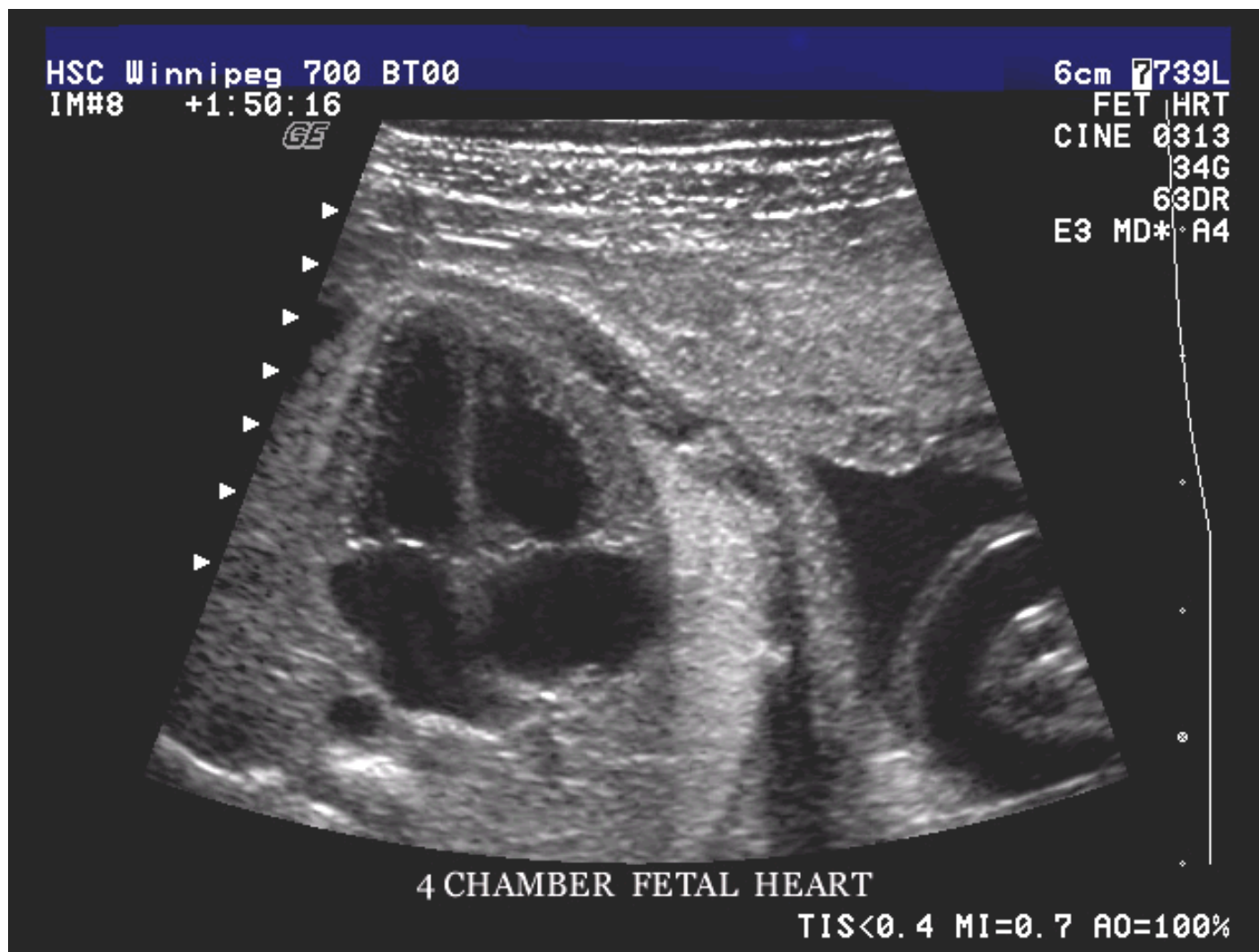
Neck of a fetus



Brain of a fetus

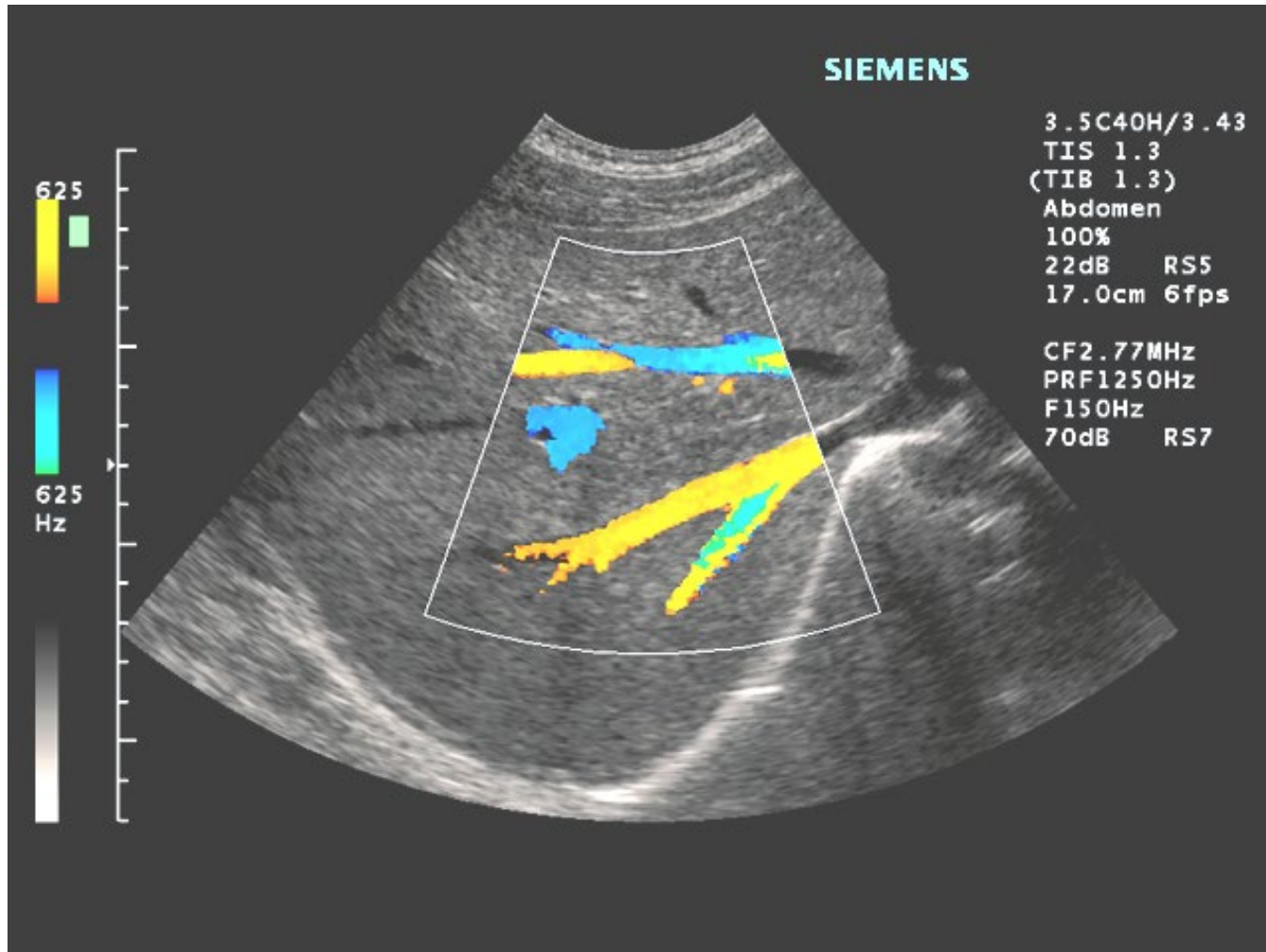


Heart of a fetus

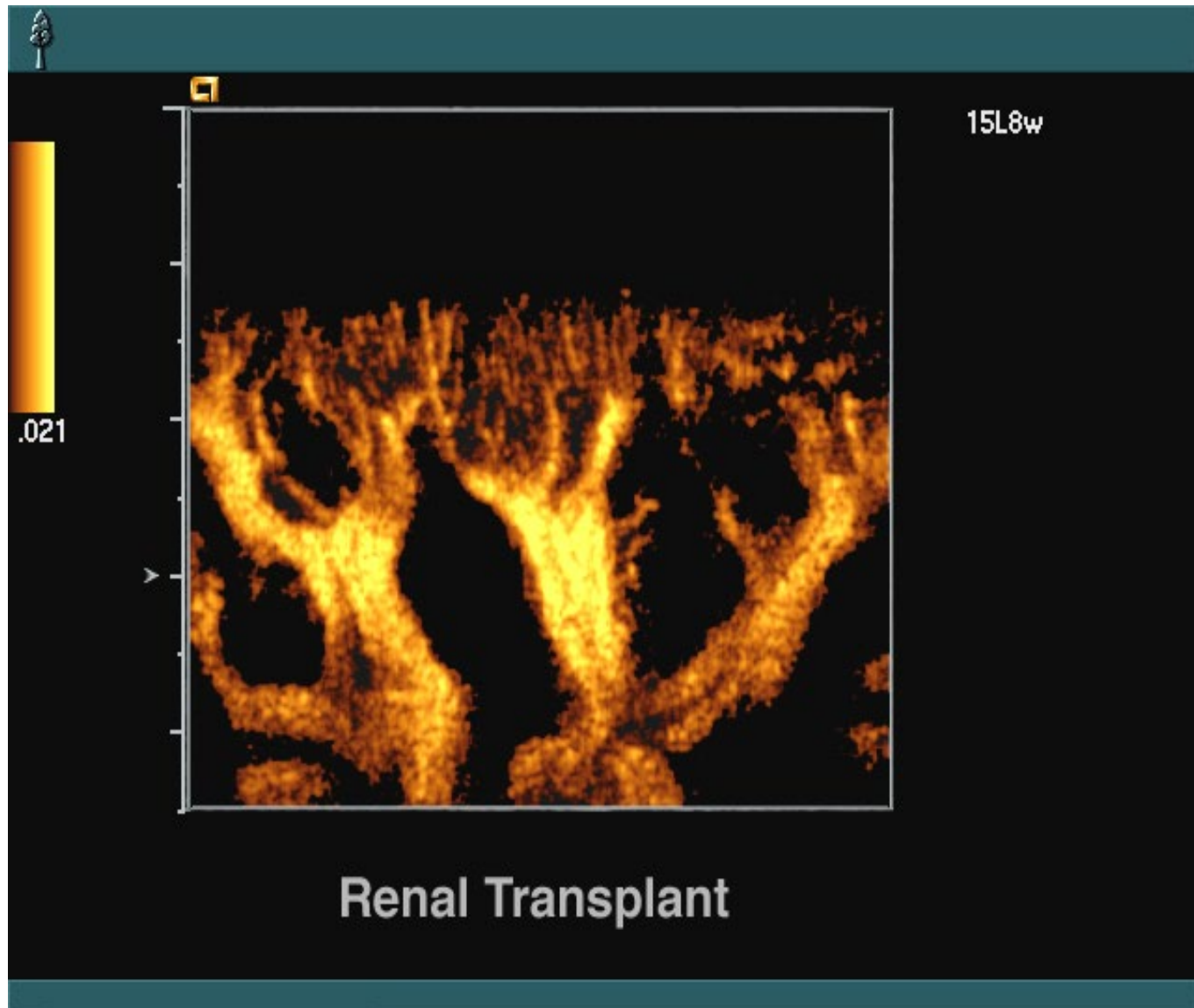


17 weeks of amenorrhea

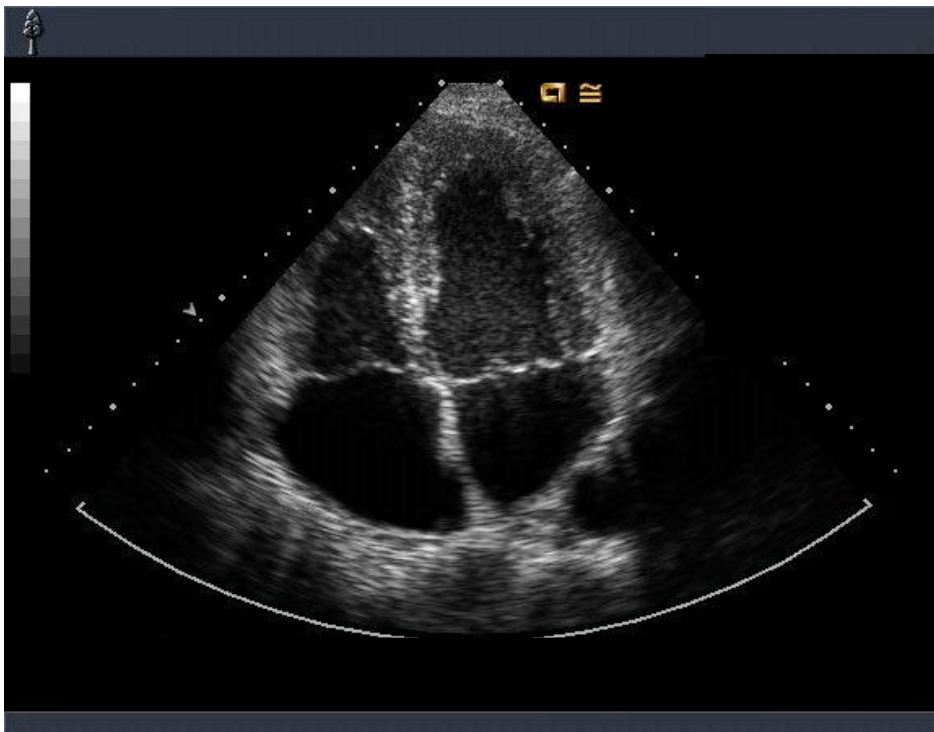
Abdominal ultrasound: liver



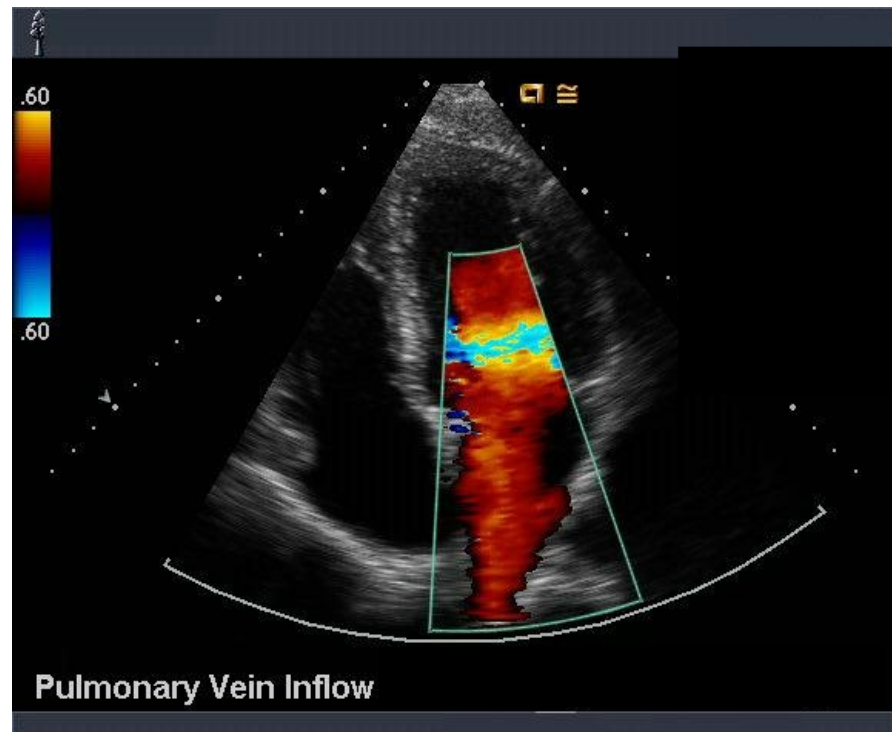
Stream flowing into a transplanted kidney



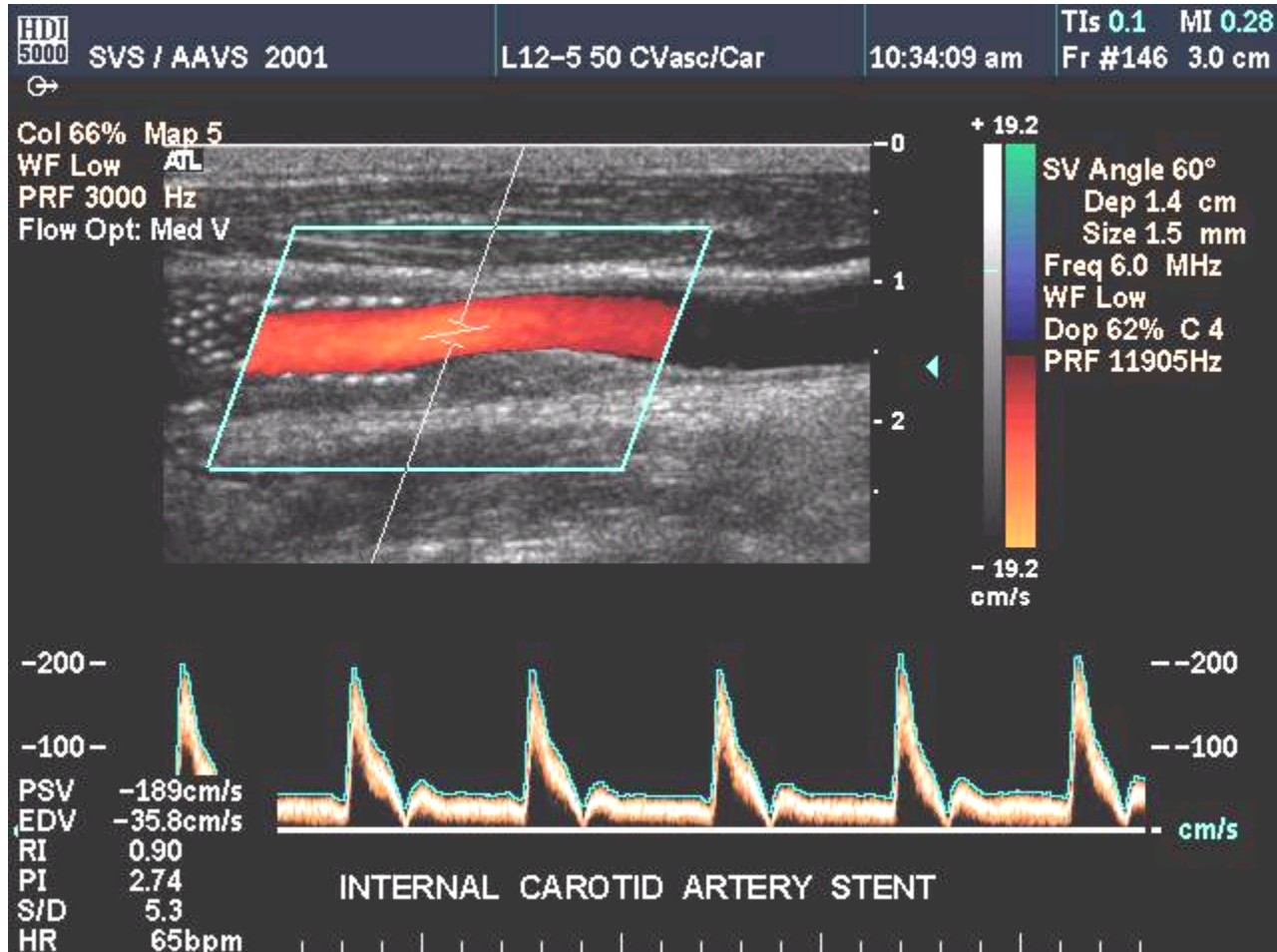
Heart (anatomy)



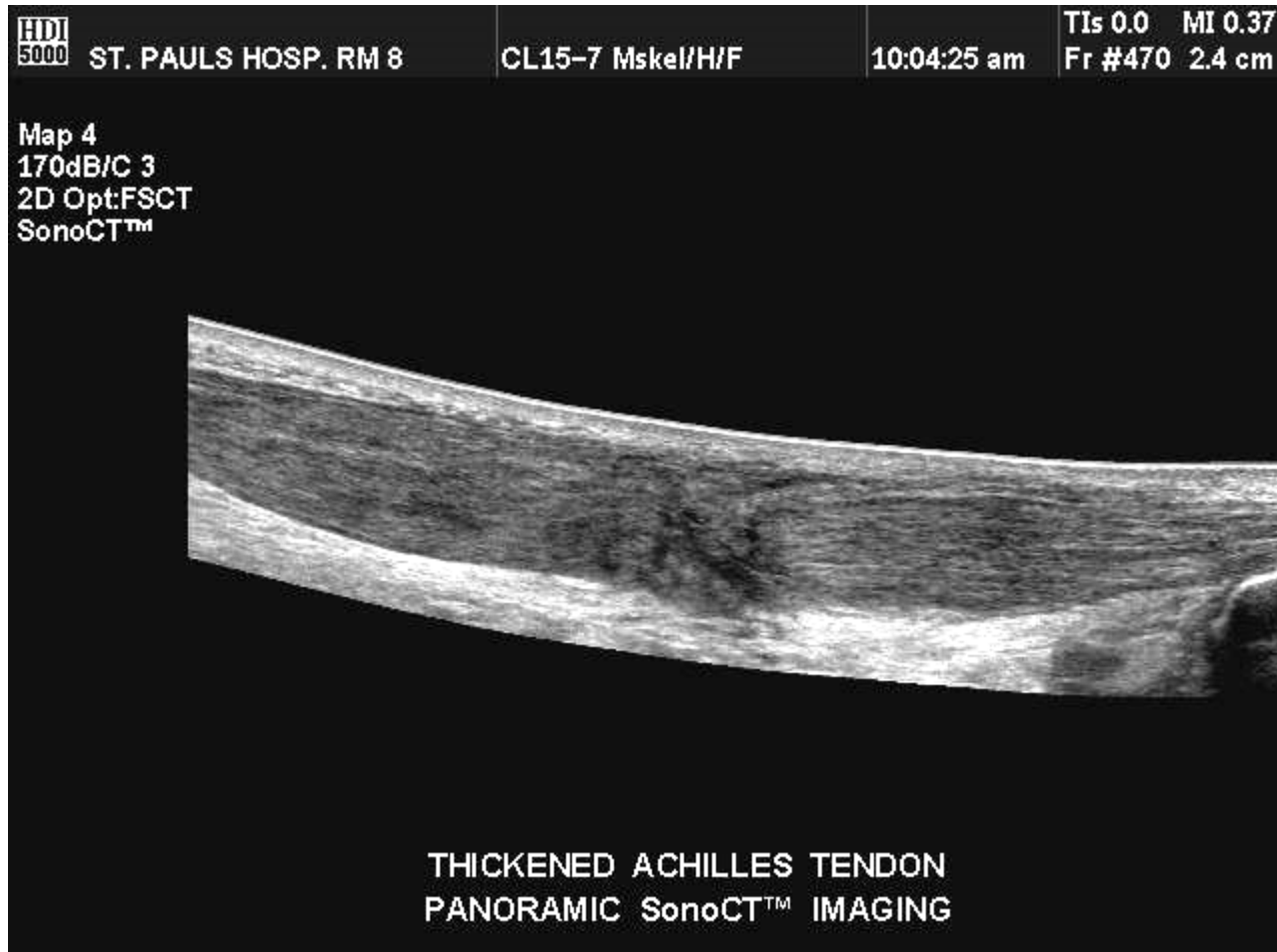
Anatomy + blood velocity



"Stent" placed in an internal carotid artery



Thickened Achilles Tendon



Classic applications but ...?

- 3 dimensional imaging
- Products
- Harmonic imaging of tissues
- Intravascular imaging, peri-operative ...

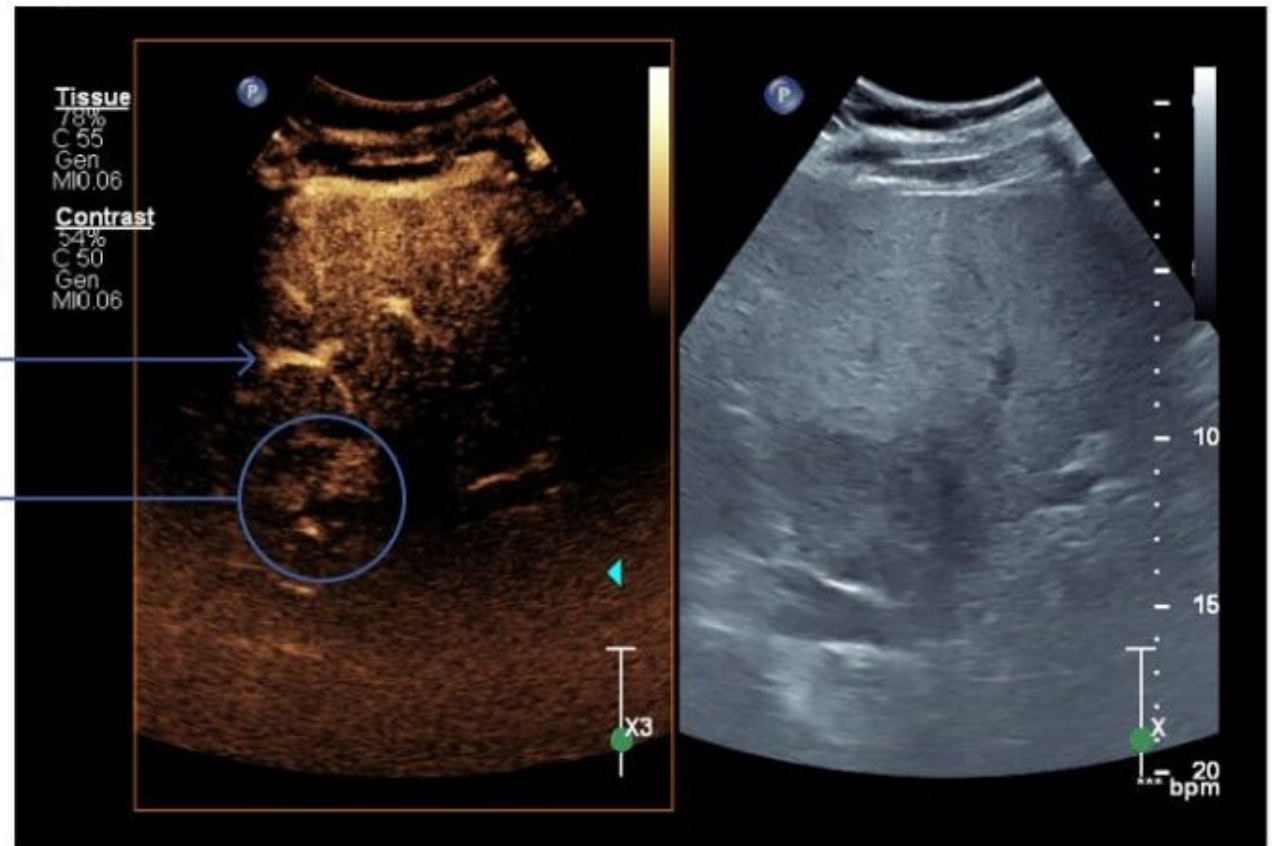
3D Imaging: surface reconstruction



Contrast agents: gas-filled microbubbles

Contrast-Enhanced

Traditional



**Blood flow in the vessels
is much clearer**

**Better able to see
blood flow to lesion**

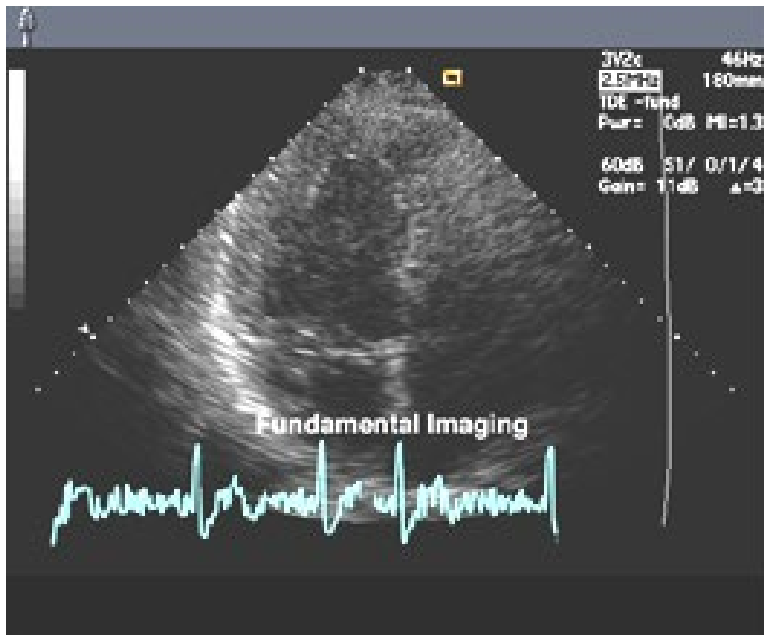
<https://blog.radiology.virginia.edu/contrast-ultrasound-what-its-used-for-and-4-key-advantages/>

Harmonic Imaging of Tissues:
transmission at frequency f , reception at frequency $2f$

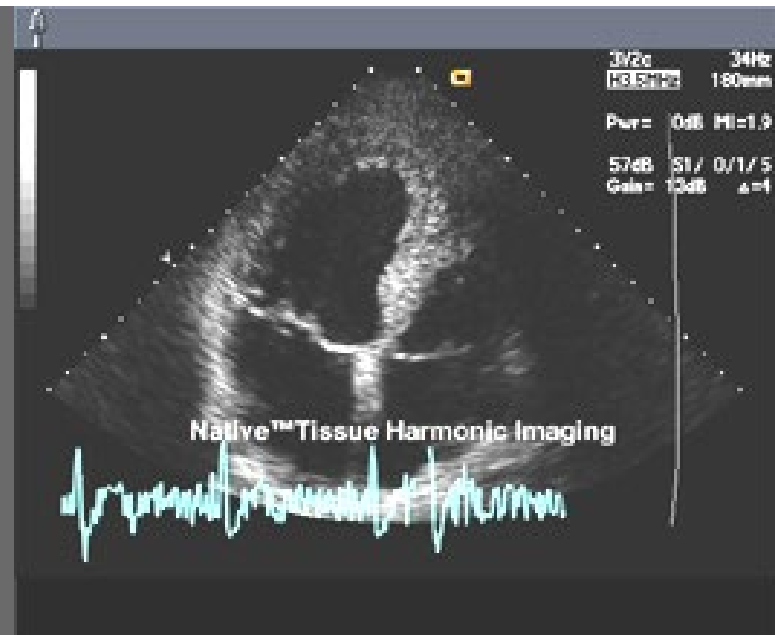
Non-linear properties of tissues:
analogy with breaking waves

Interest in Patients Deemed "Difficult » to image

heart

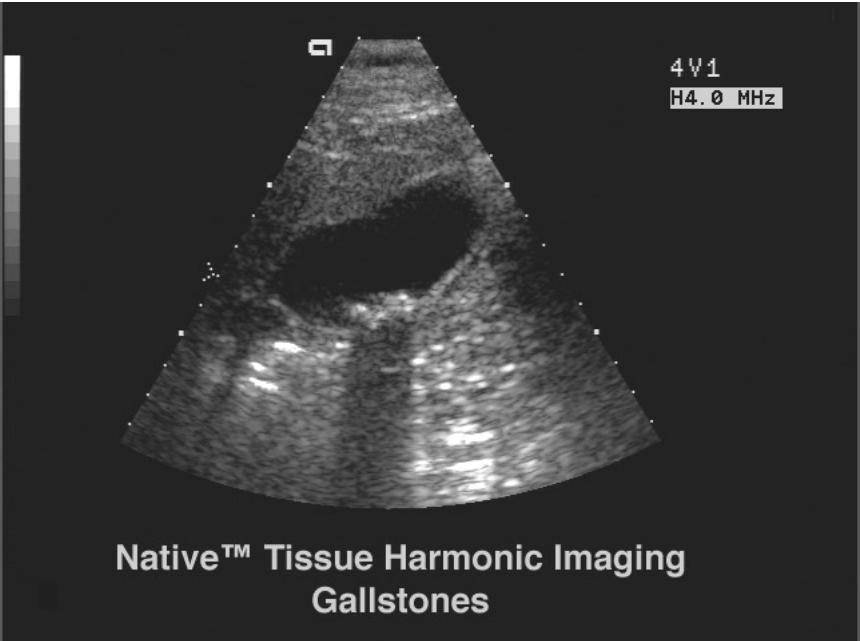
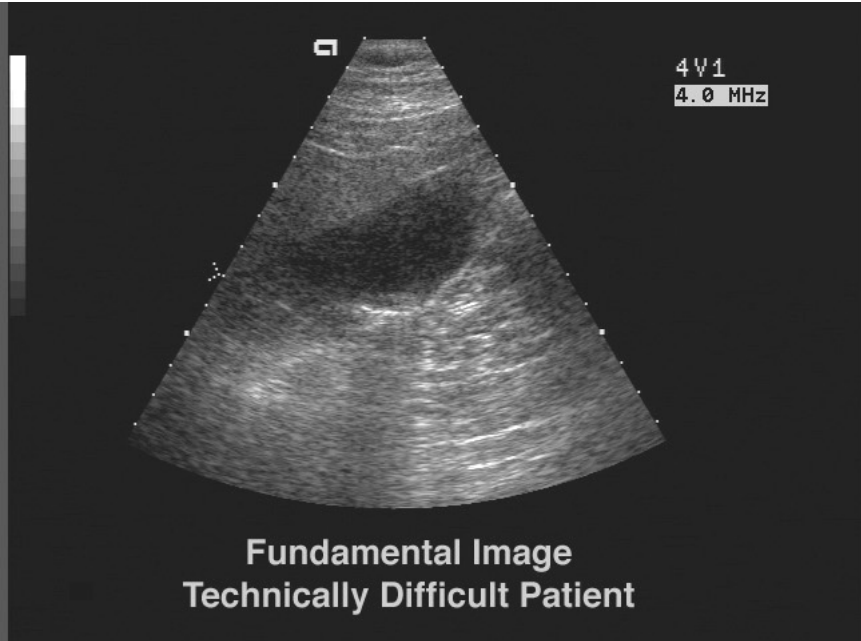


Classical (fundamental)

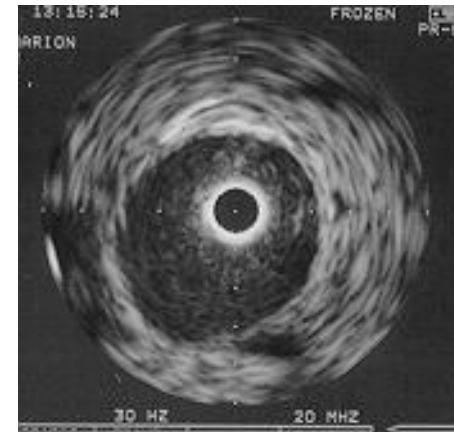
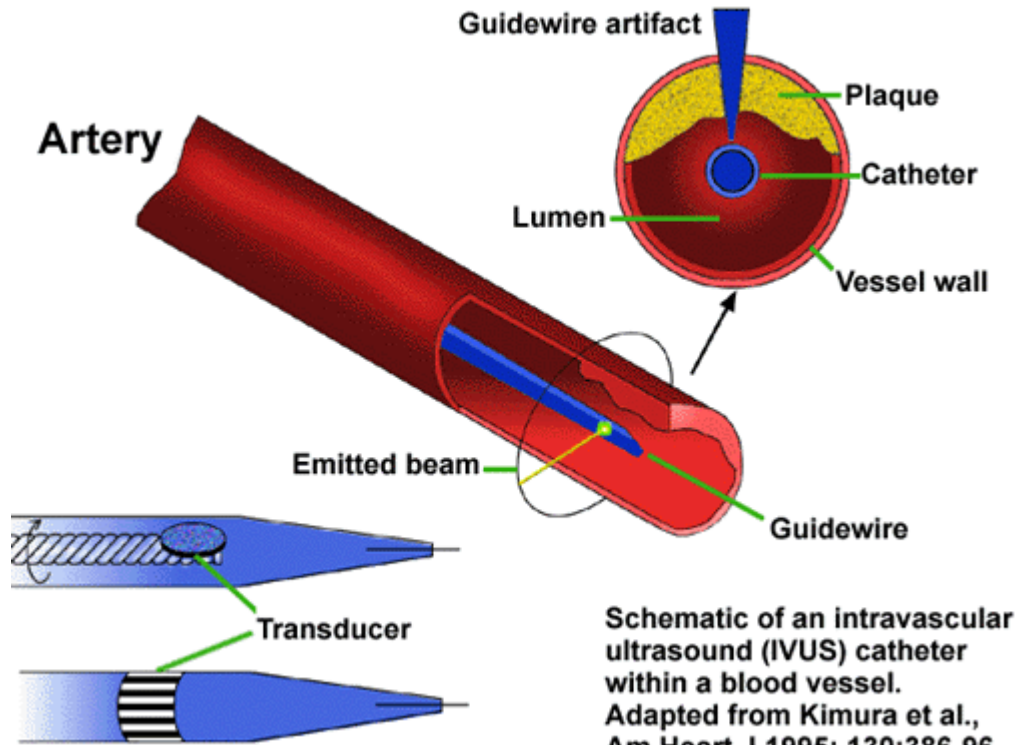


Second harmonic

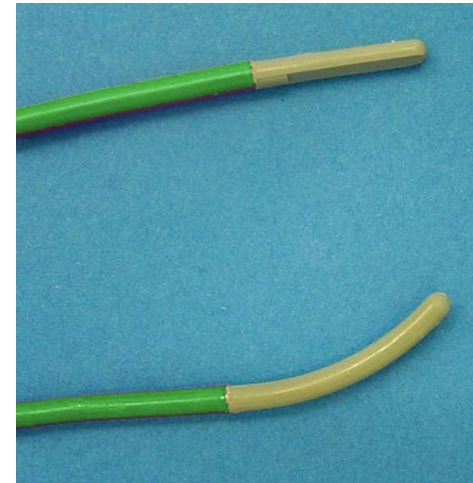
Harmonic imaging: kidney stones (acoustic shadow)



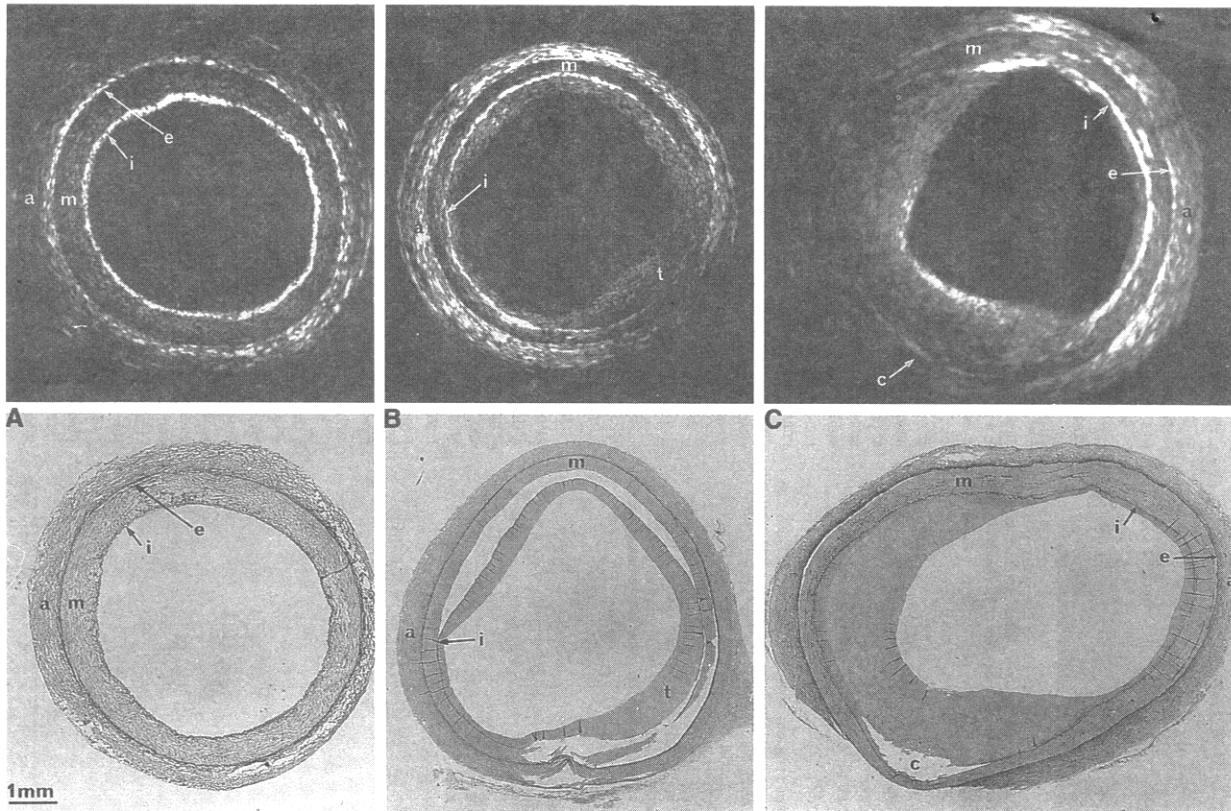
Intravascular, intracardiac, peri-operative imaging. intracardiac



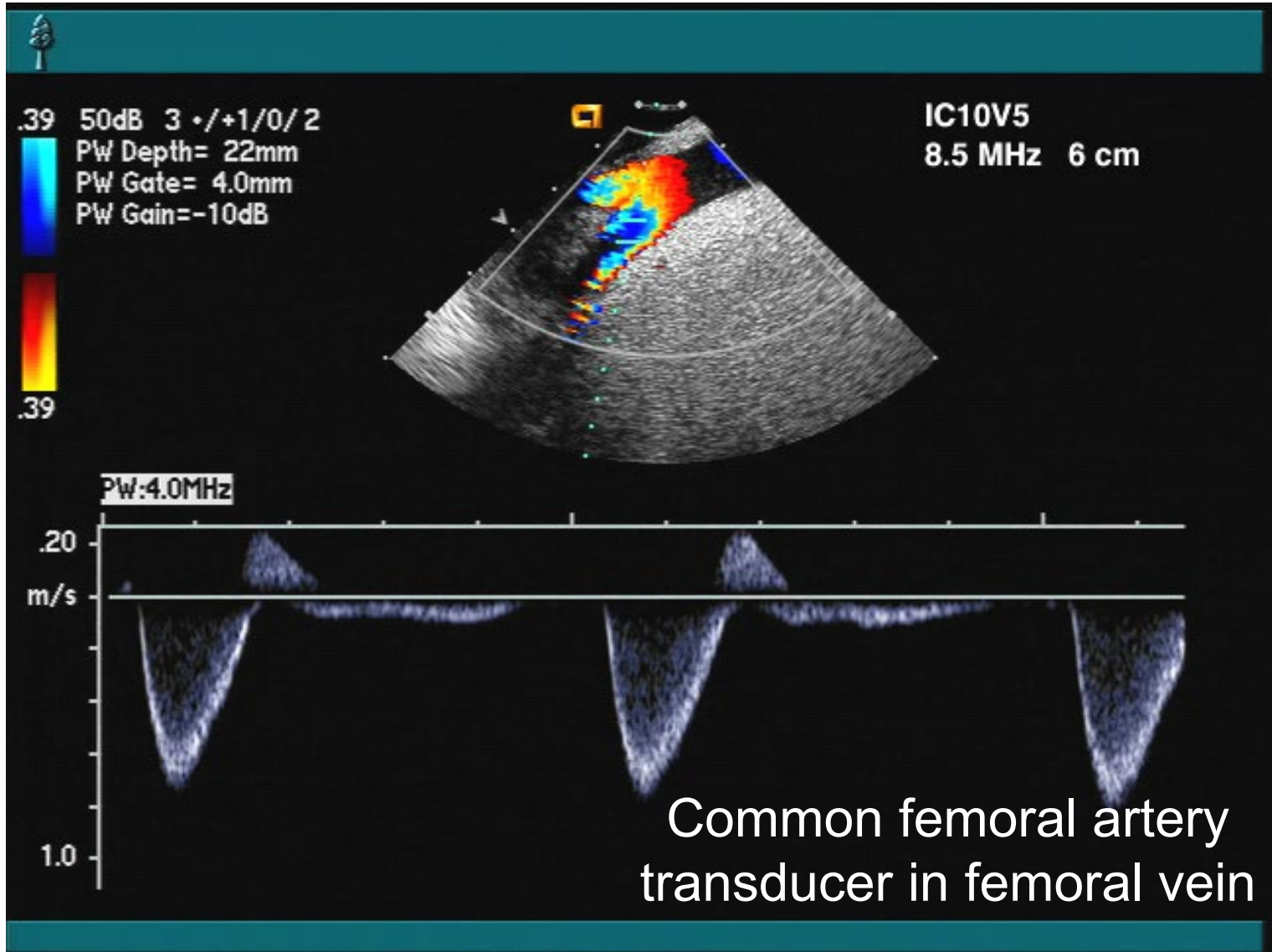
Intravascular, intracardiac, peri-operative imaging:
miniature, sterilizable or disposable probes
at the end of a catheter (diameter 1-3 mm)



Intravascular imaging: ex-vivo images

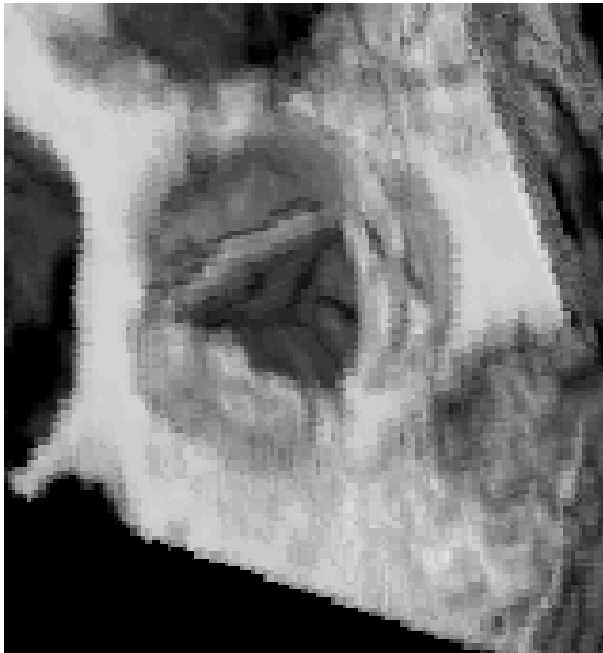


In-vivo intravascular imaging: circulation in the femoral artery (probe in the femoral vein)

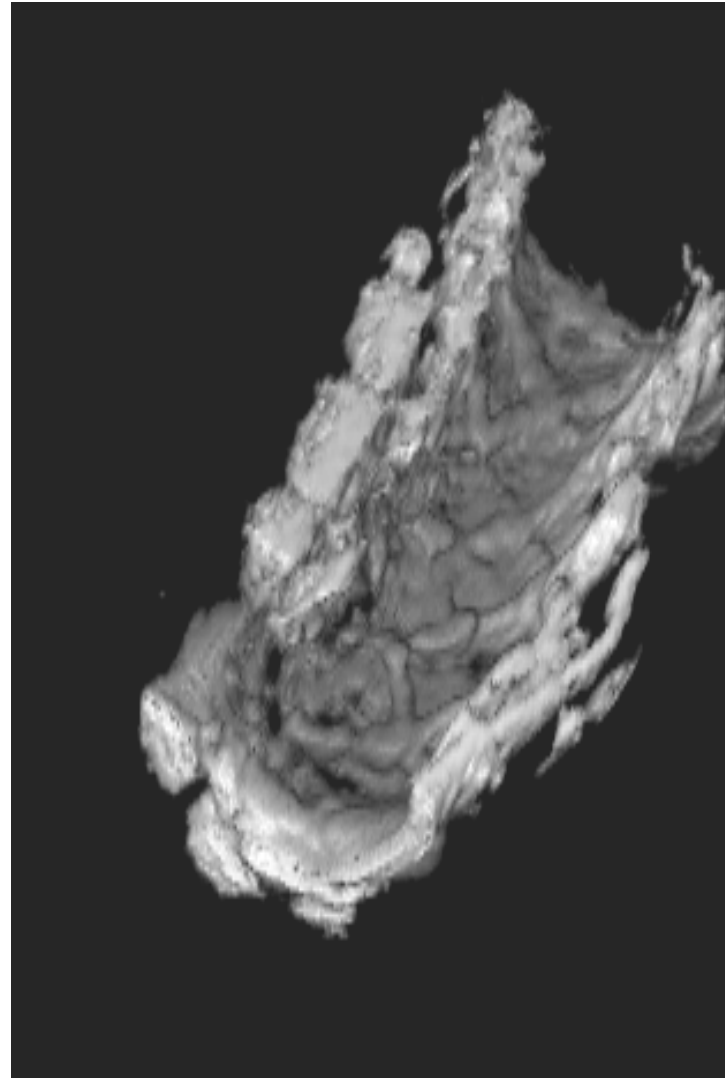


Intravascular 3D imaging

Aortic valve



Intravascular « stent »



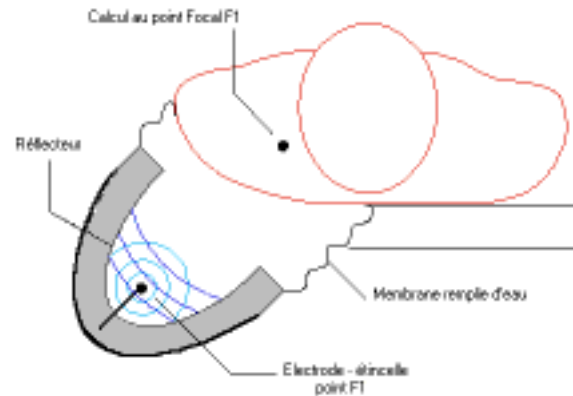
THERAPEUTIC APPLICATIONS: effects of ultrasound on biological tissues

- Heating
 - when a wave propagates, there is friction between particles of matter, from which a production of heat
- cavitation
 - when a gas bubble is subjected to a high power acoustic wave, there is cavitation: it can implode and thus destroy the surrounding tissues
- Shock waves
 - an acoustic wave of very short duration and very high energy is called shock wave (eg explosion); it can destroy objects, especially if they are hard (rigid)

THERAPEUTIC APPLICATIONS

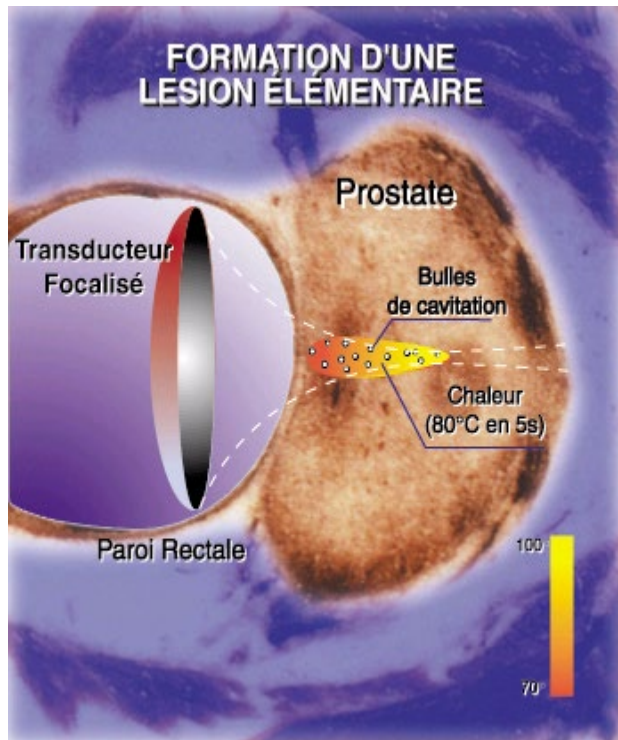
LITHOTRIPSY

- Ultrasound of very high intensity, very focused and very short durations SHOCK WAVES
- Destruction of any very hard structure / biological tissues: stones



Extracorporeal
lithotripter Spark
ESWL® EM

THERAPEUTIC APPLICATIONS: ABLATHERMIA



Equipment: ultrasound and therapy



Conclusions

As a result, ultrasound has been successful (€ 2 billion turnover)

- No ionizing radiation
- Generally non-invasive
- Real-time
- Resolution 0.1 to 3 mm
- Low cost (1k€ to 150 k €)
- Multi-use, portable, reliable

Perspectives

- A permanent evolution towards
 - better resolution images
 - richer information (volume, movement)
 - the exploration of new organs
- Adding new modalities / techniques
 - Harmonic imaging
 - Characterization of tissues (quantification)
 - Elasticity of tissues (deep palpation)
 - imaging of the brain ?