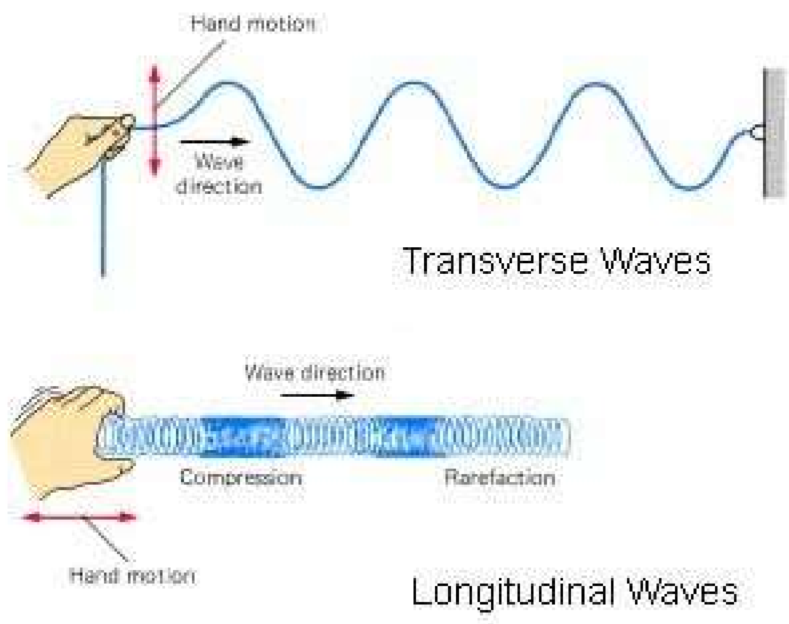
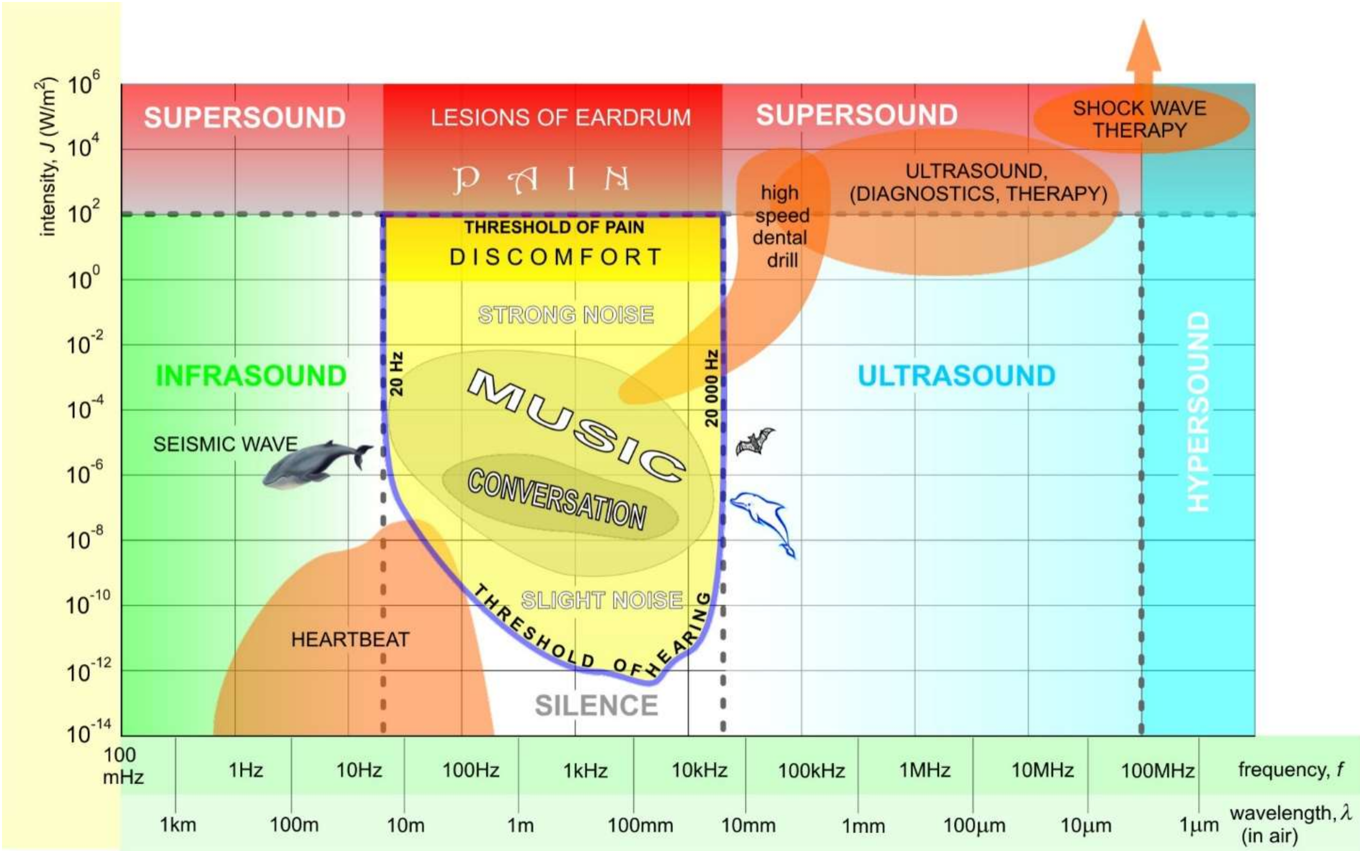
Ultrasound

Ultrasound: mechanical wave, f > 20 kHz.
Mechanical waves (sound, ultrasound) require medium for spreading.



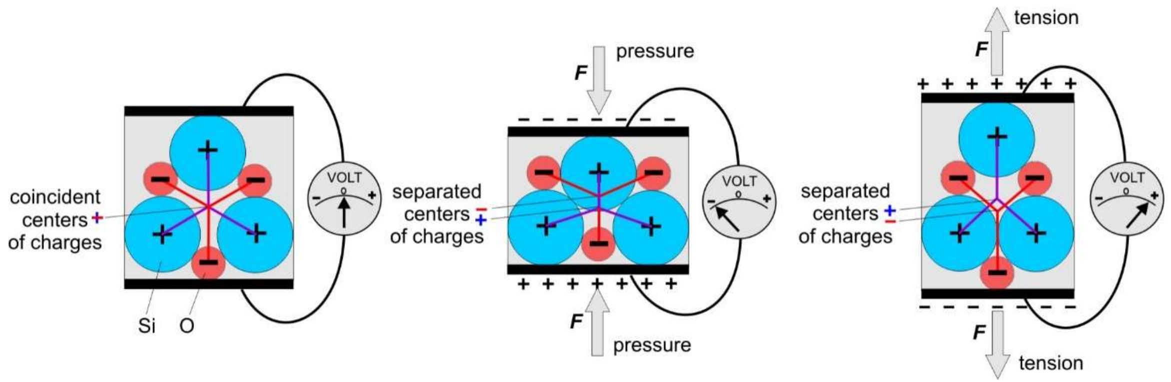
Frequency and intensity ranges of mechanical waves

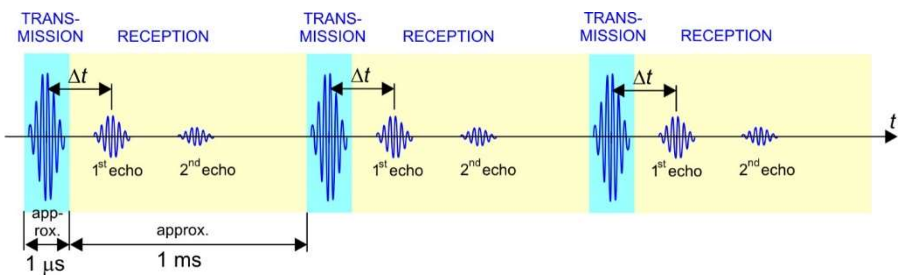


Production by piezoelectric crystal

- Direct piezoelectric effect: charge separation due to mechanical effect. – detection of ultrasound

- Inverse piezoelectric effect: putting alternating voltage on the crystal it starts mechanical vibration. – production of ultrasound





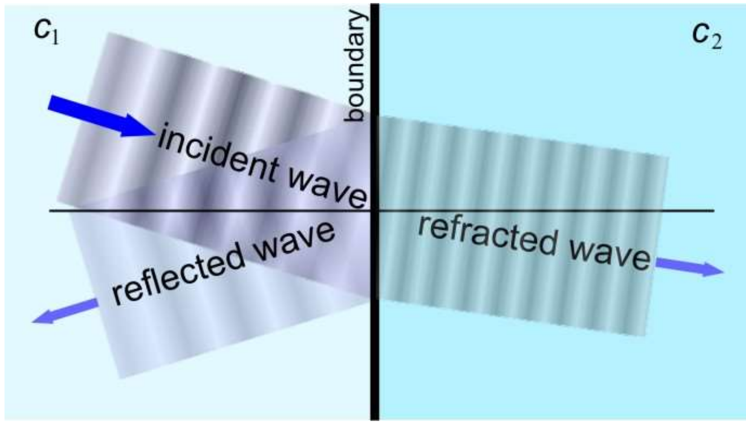
Medical application:

- Diagnostics: f = 1 – 10 MHz, in ophthalmology and for short distance 20 MHz, J ~ mW/cm^2

- Therapy: f = 0,8 – 1,2 MHz, J ~ W/cm^2

Basis of diagnostic application is the reflection of ultrasound from boundaries of different media

$$R = \frac{J_{back}}{J_{in}}$$



$$R = \left(\frac{\rho_1 c_1 - \rho_2 c_2}{\rho_1 c_1 + \rho_2 c_2} \right)^2$$

$\rho c = Z$ (acoustic impedance)

Total reflection on solid/gas or liquid/gas boundaries (because of this coupling medium (e.g. contact gel) is applied)

The absorption of ultrasound is also important

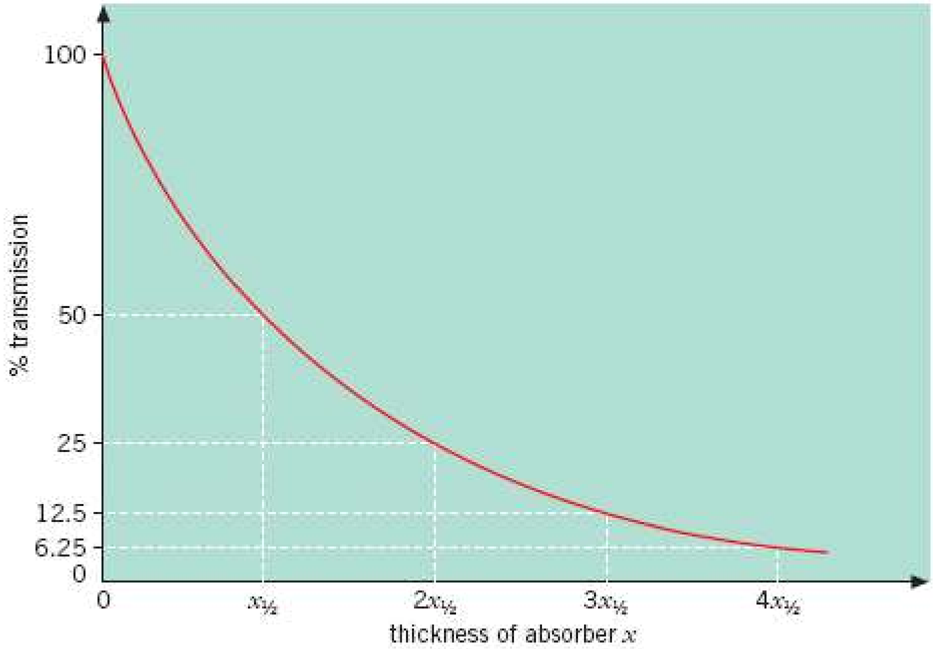


Figure 14.6 The percentage transmission of ultrasound in a medium

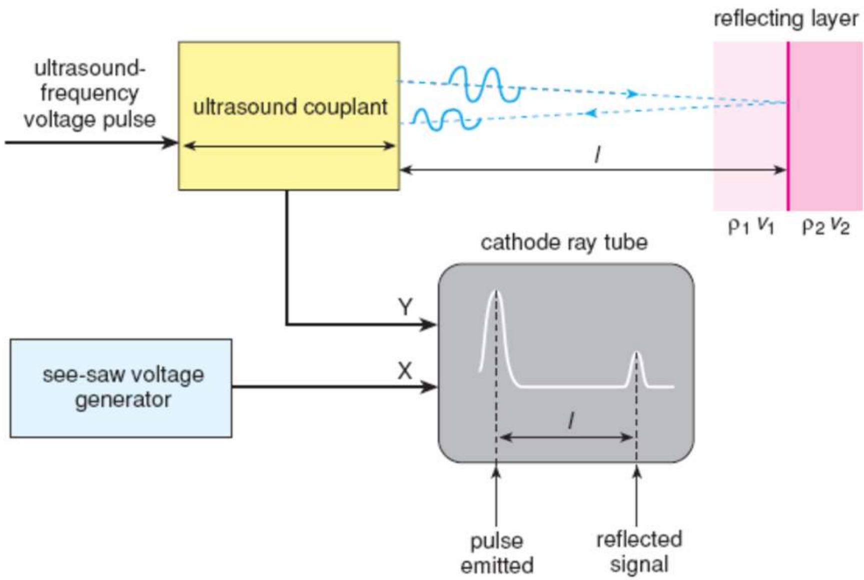
The law of attenuation is valid.

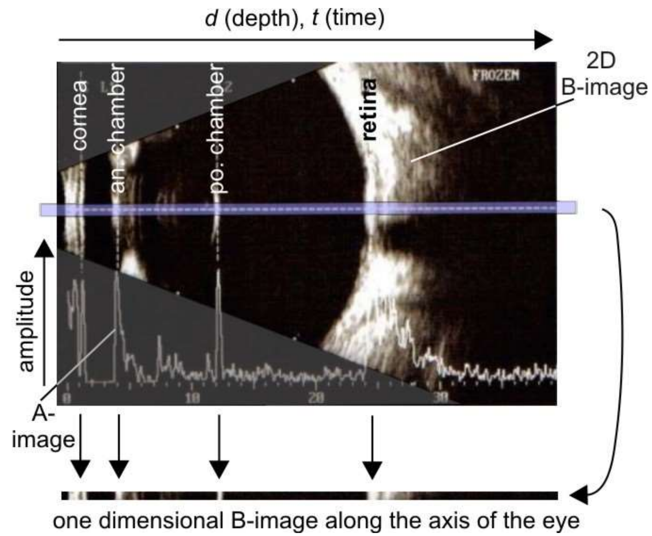
In the frequency range of diagnostics the absorption is directly proportional to the frequency

Higher frequency:
- better resolution
- shorter effective range

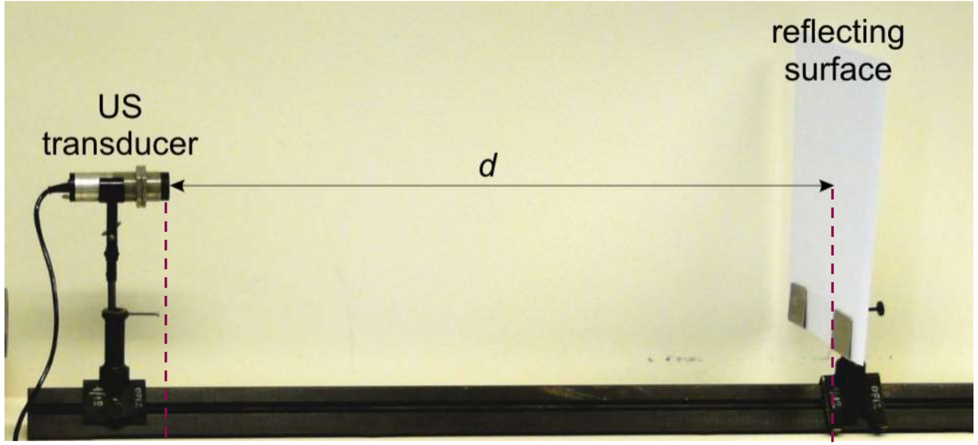
A-image (amplitude image)

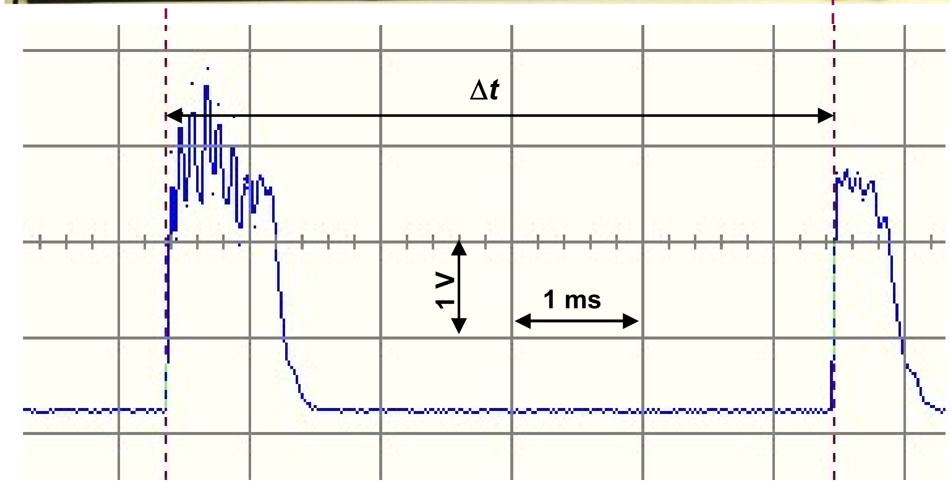
- Distance measurement (applied mainly in ophthalmology)





The pulse echo principle





During the time of Δt the US pulse propagates a distance of 2*d*, thus the distance *d* is given by:

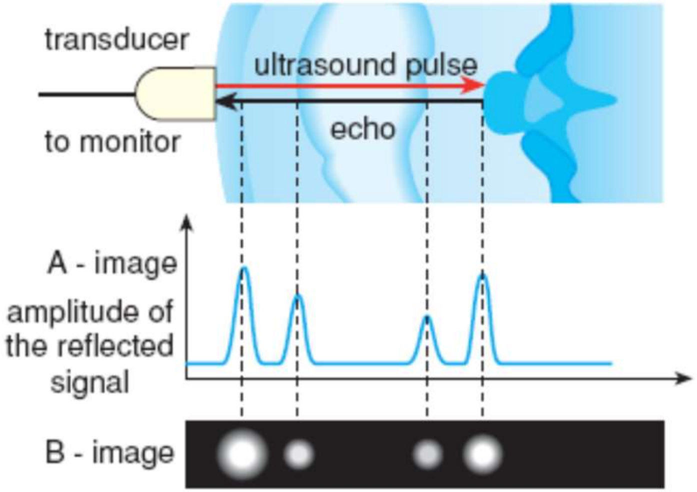
$$d = \frac{c \cdot \Delta t}{2}$$

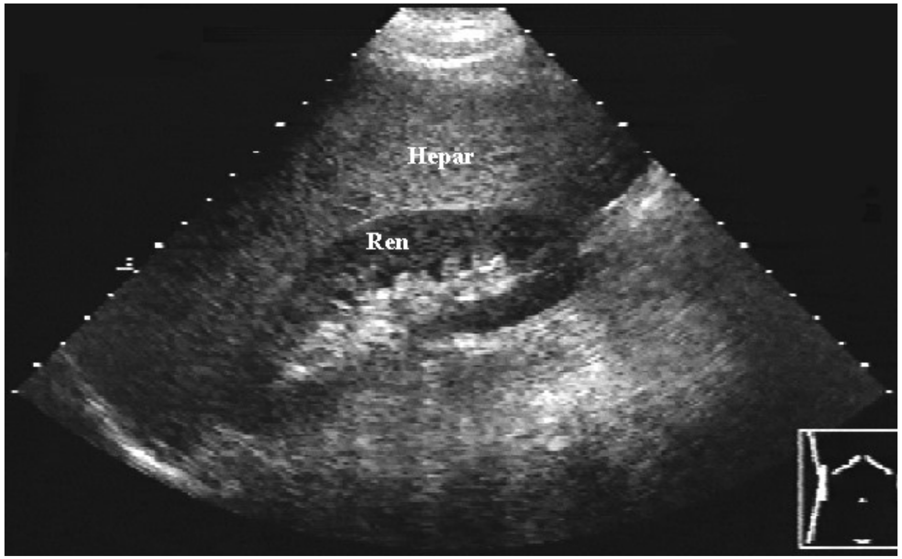
Medium	Speed of sound, *c* (m/s)
Air (20 °C)	343
Water (20 °C)	1482
Soft tissue	1540

From a special transducer a part of ultrasound can be conducted to air.

B-image (brightness)

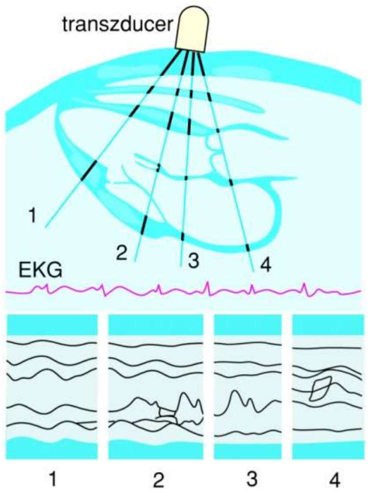
- Brightness of the image point depends on the reflection

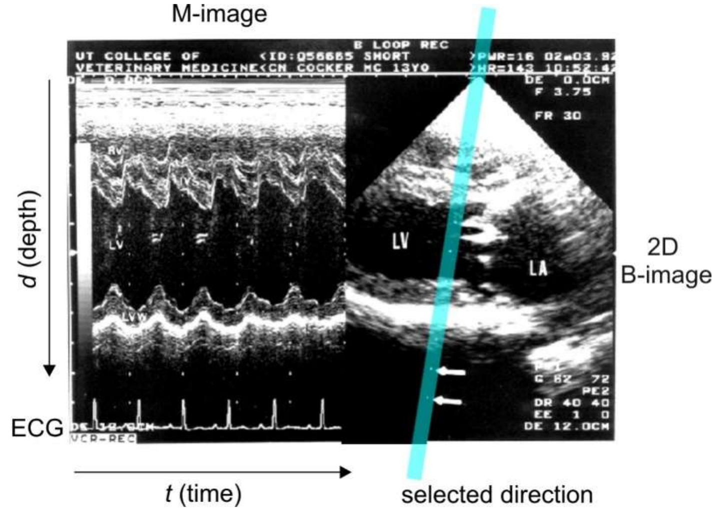




M-image (motion) – TM-image (time motion)

- The position of reflecting surface changes in time (echocardiography)
  change of one-dimensional B image in the function of time

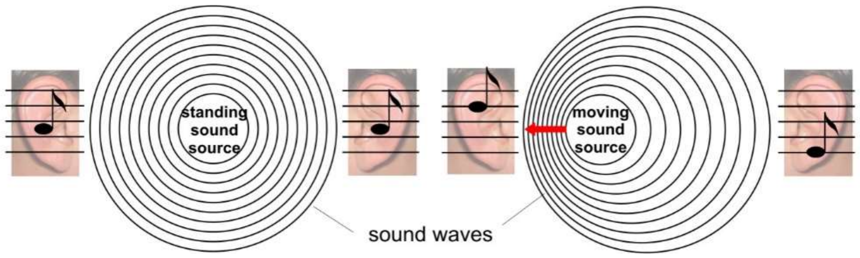




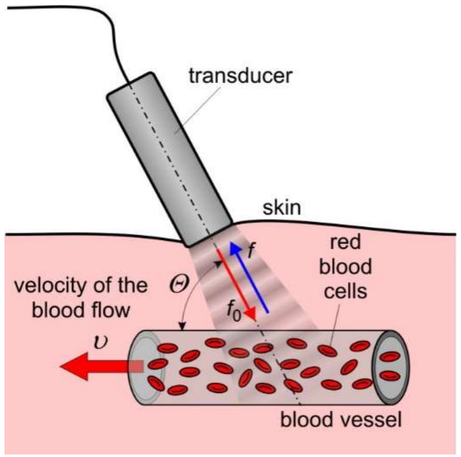
Examination of motion on the basis of Doppler principle

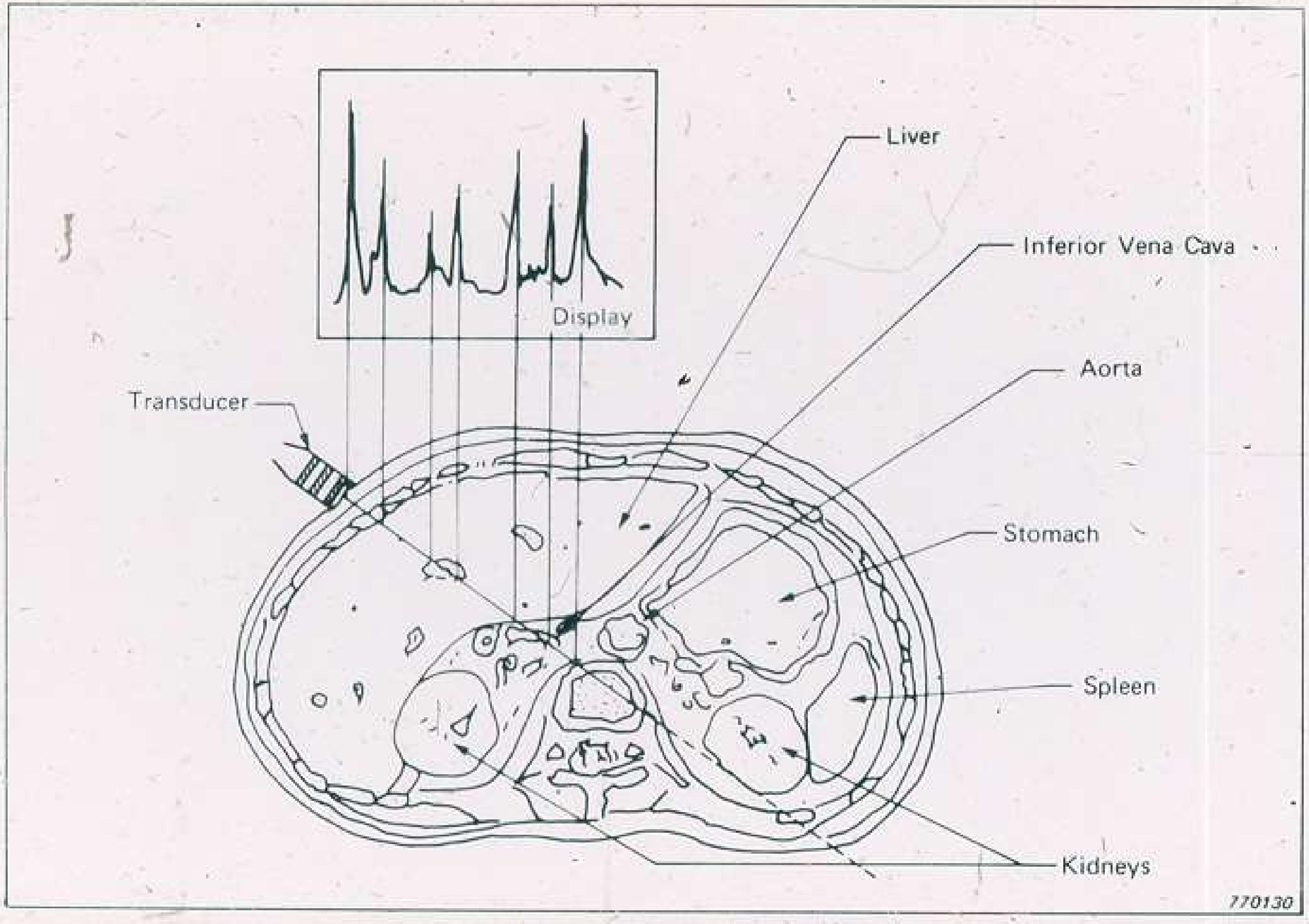
- Frequency of sound (ultrasound) changes, if the sound source or reflecting surface is moving.

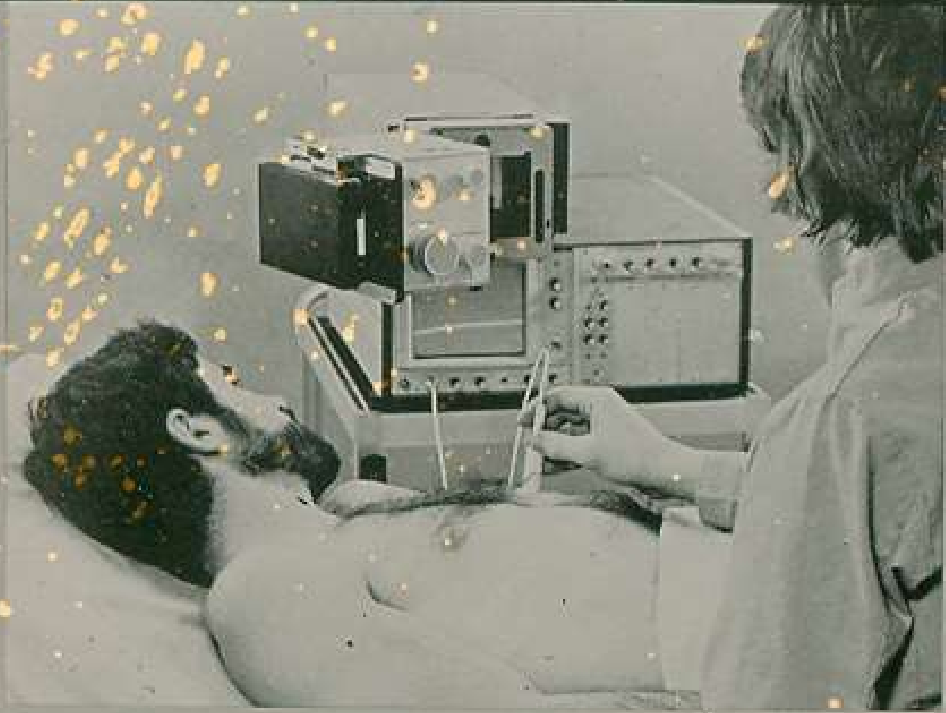
$$f = f_0\left(1 \pm \frac{2v}{c}\right)$$



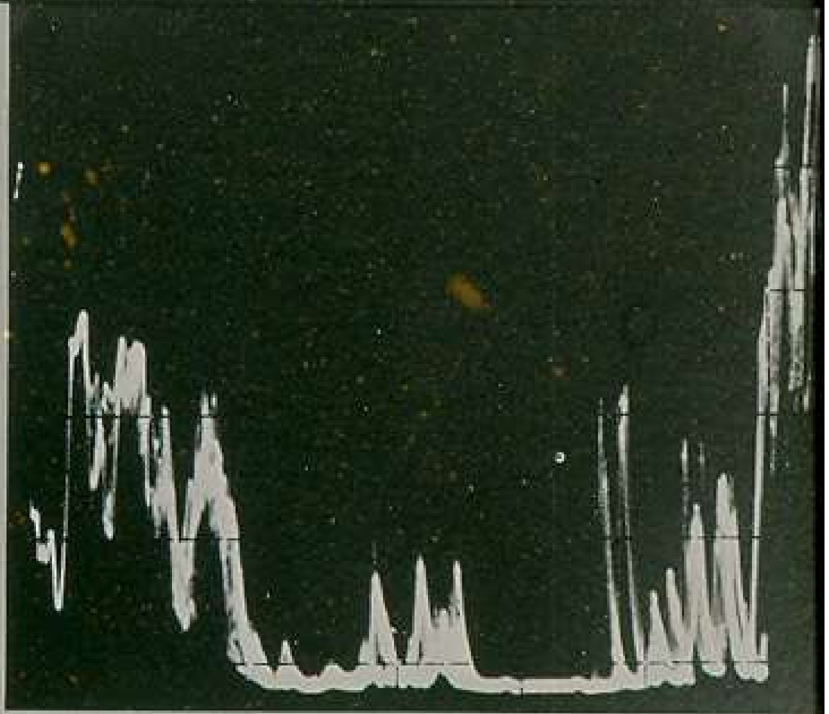
The difference between the original and reflected frequency is in the audible sound range – the sound of motion can be heard when we put it to headphone or loudspeaker (examination of blood flow in blood vessels and examination of fetal heart)



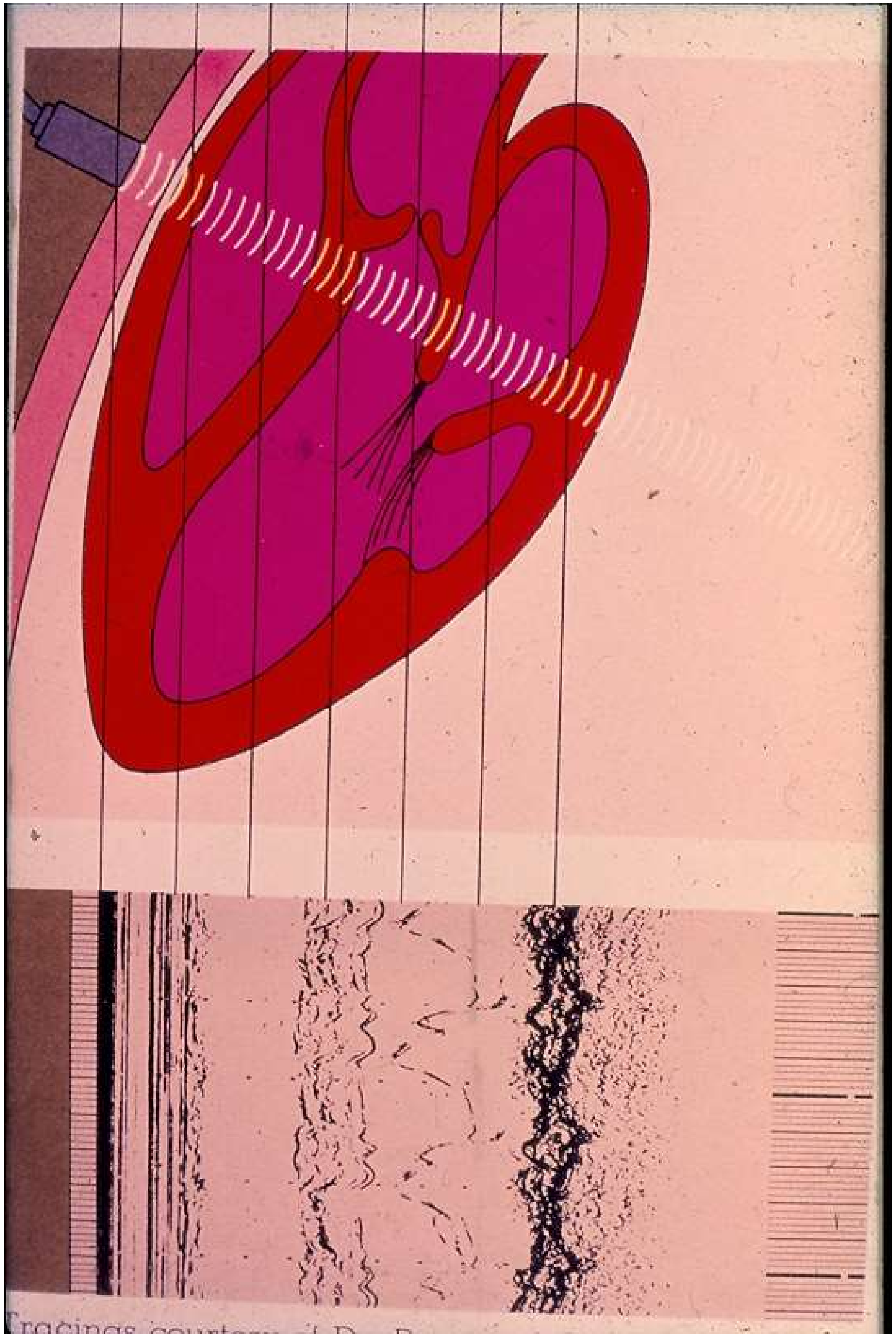

Display
Liver
Inferior Vena Cava
Aorta
Transducer
Stomach
Spleen
Kidneys
770130

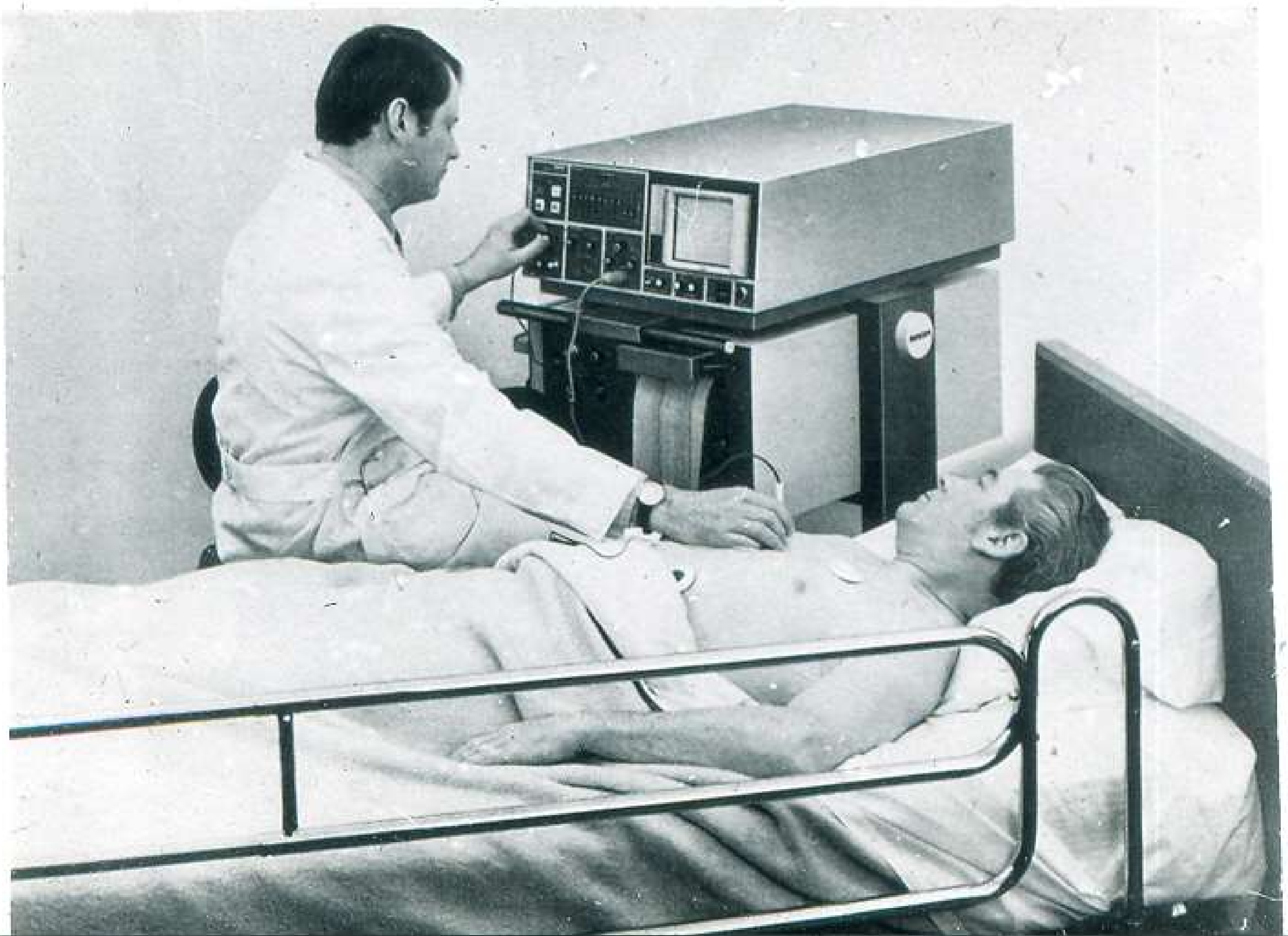


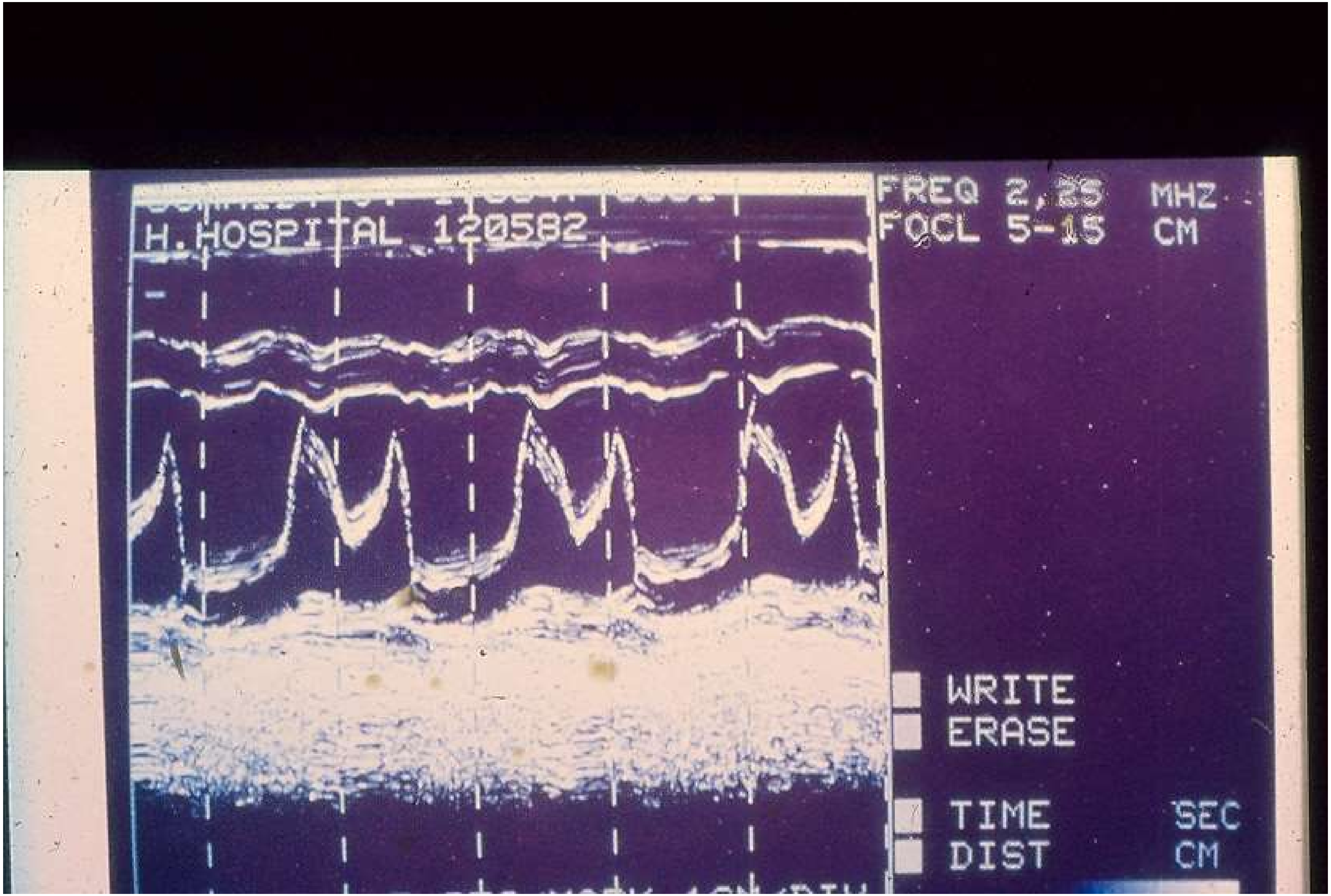
Cardiac System in clinical use

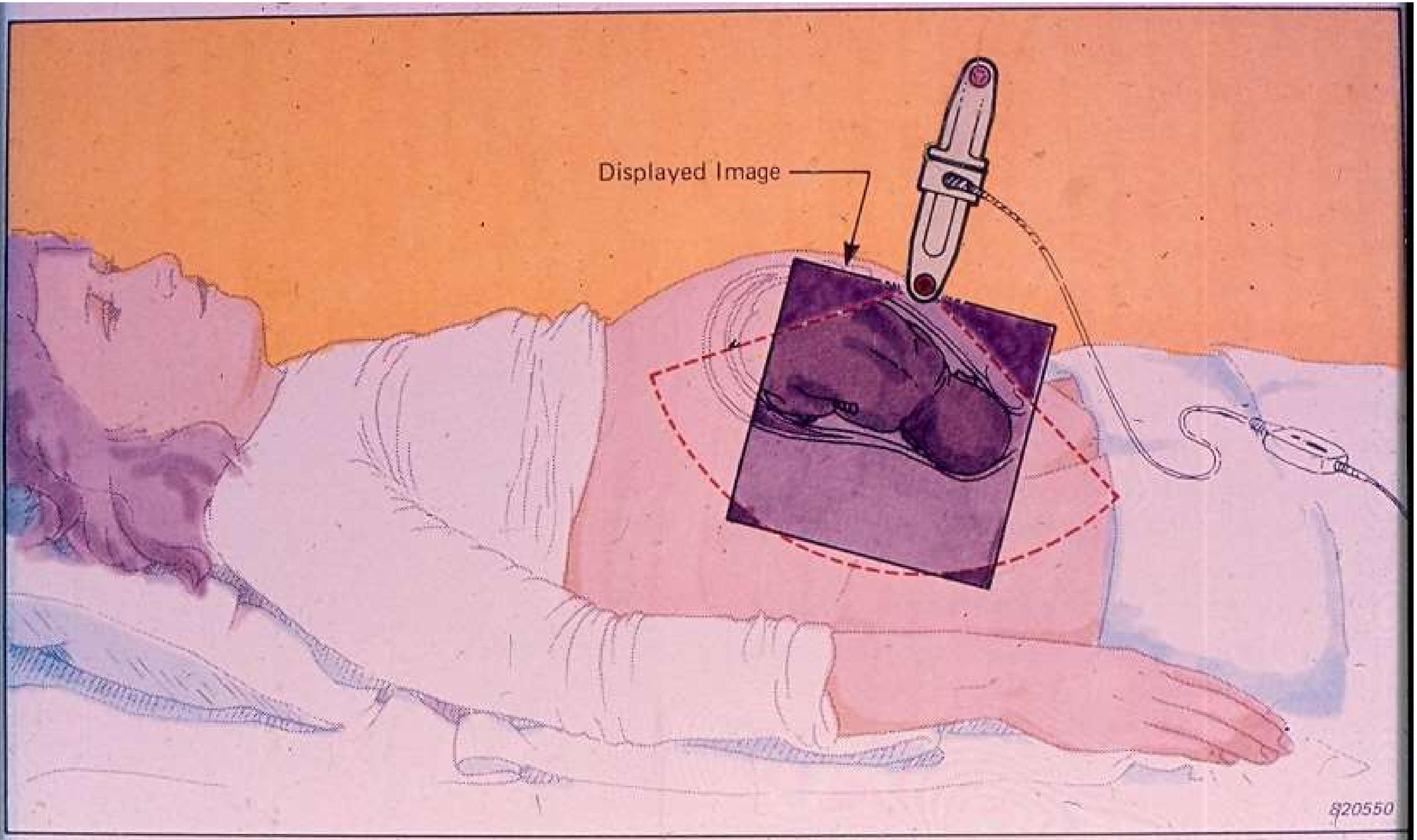


A-mode display of the mitral valve

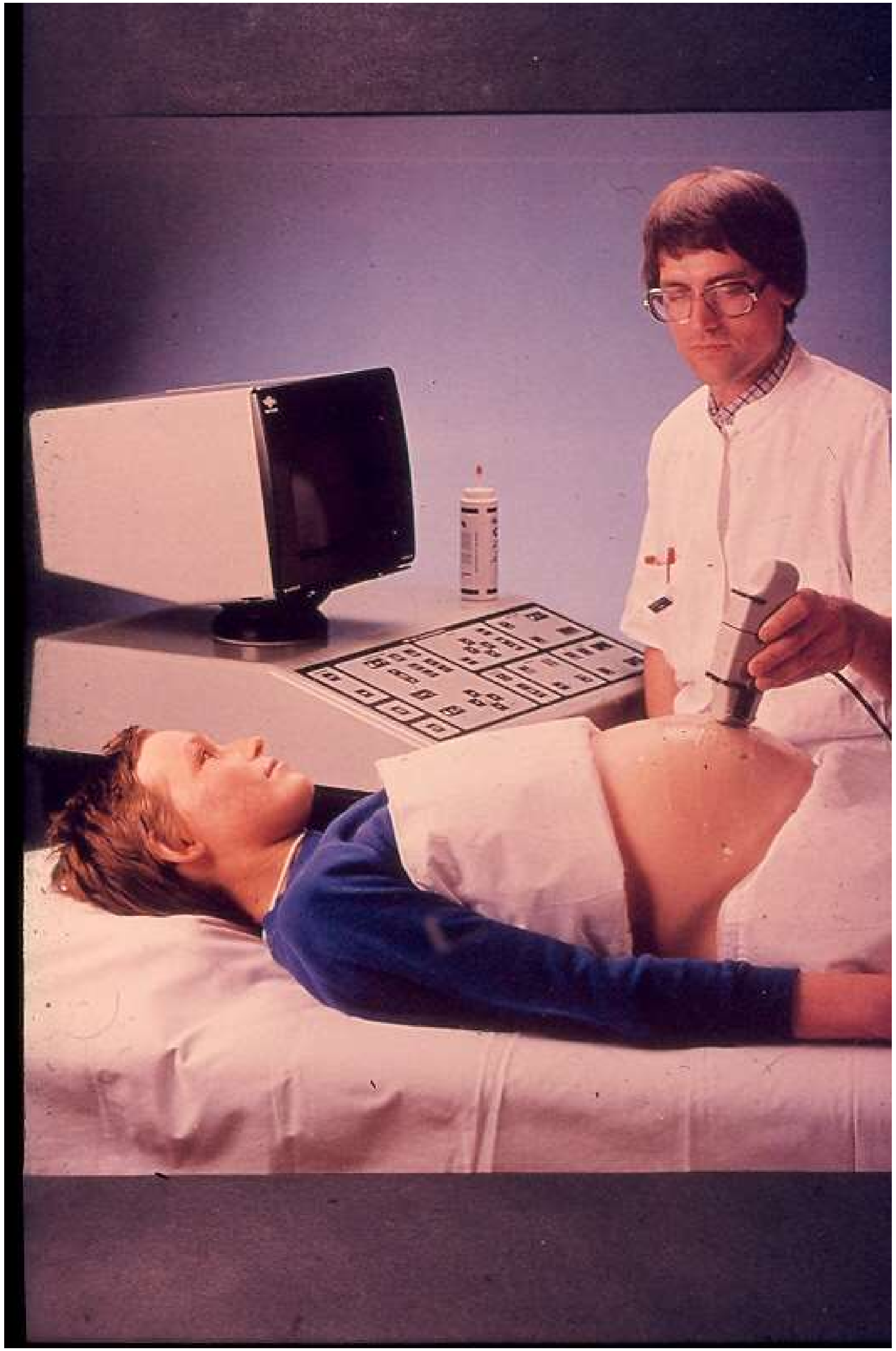

Tracings courtesy

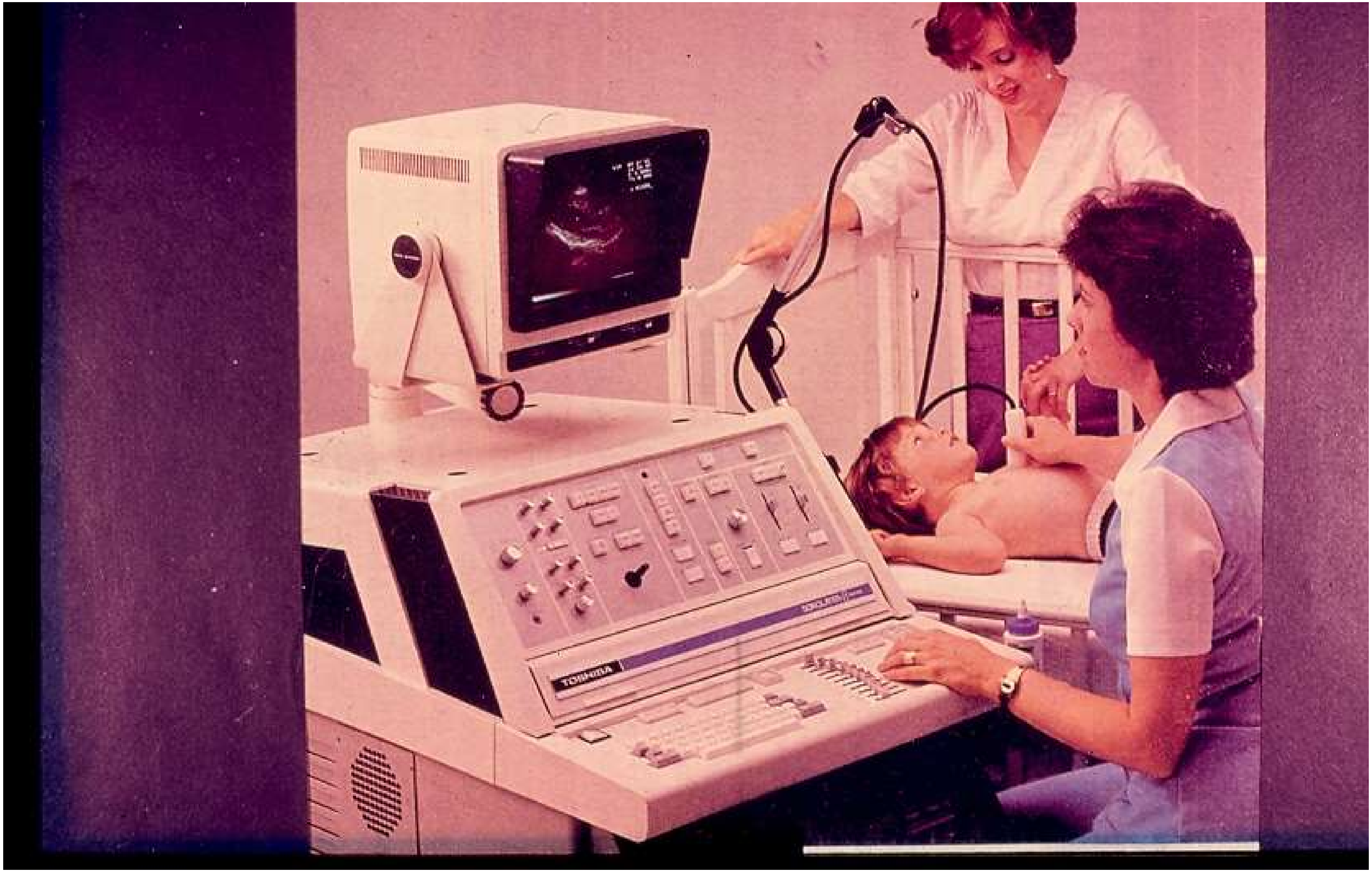


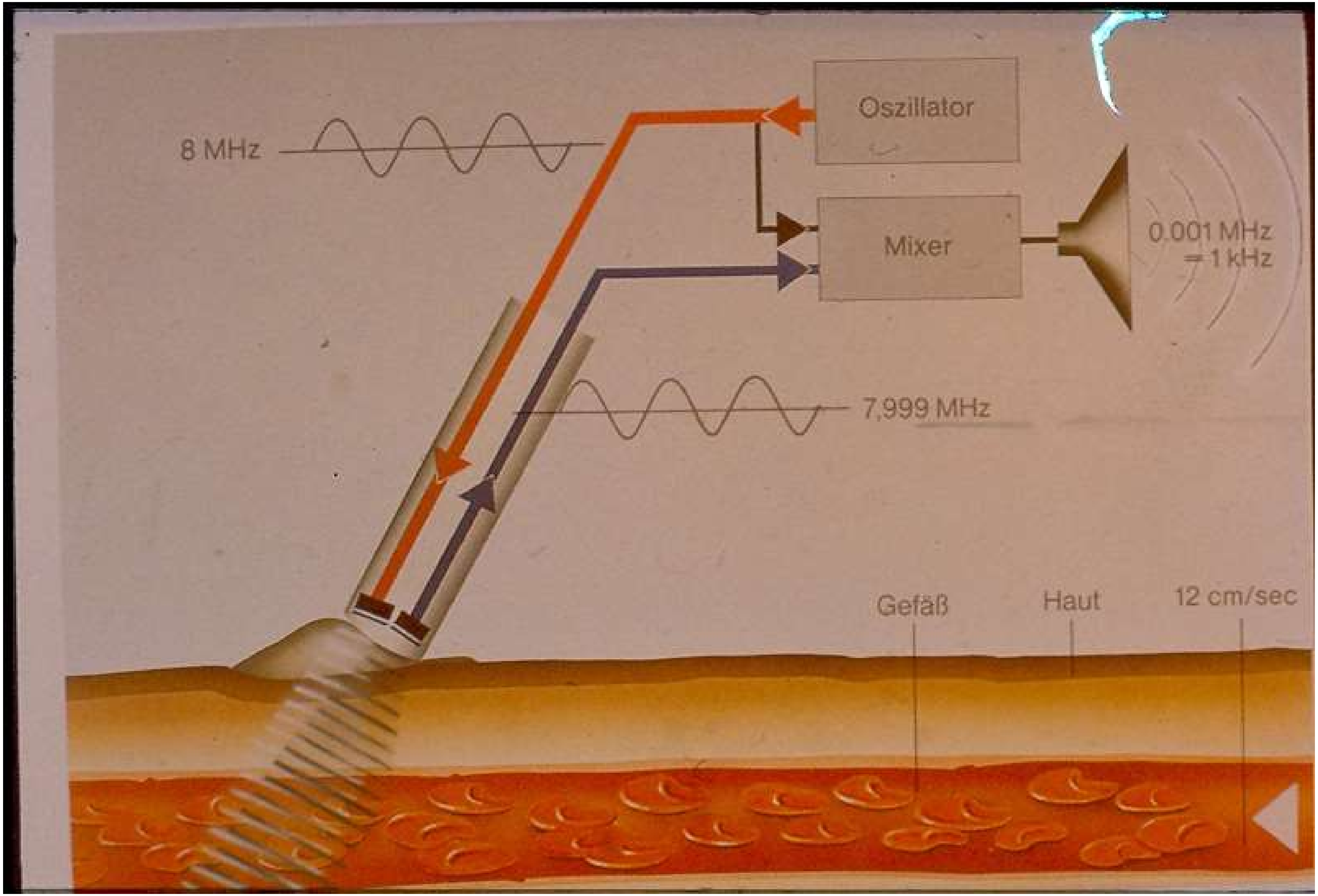

H.HOSPITAL 120582
FREQ 2.25 MHZ
FOCL 5-15 CM
WRITE
ERASE
TIME SEC
DIST CM



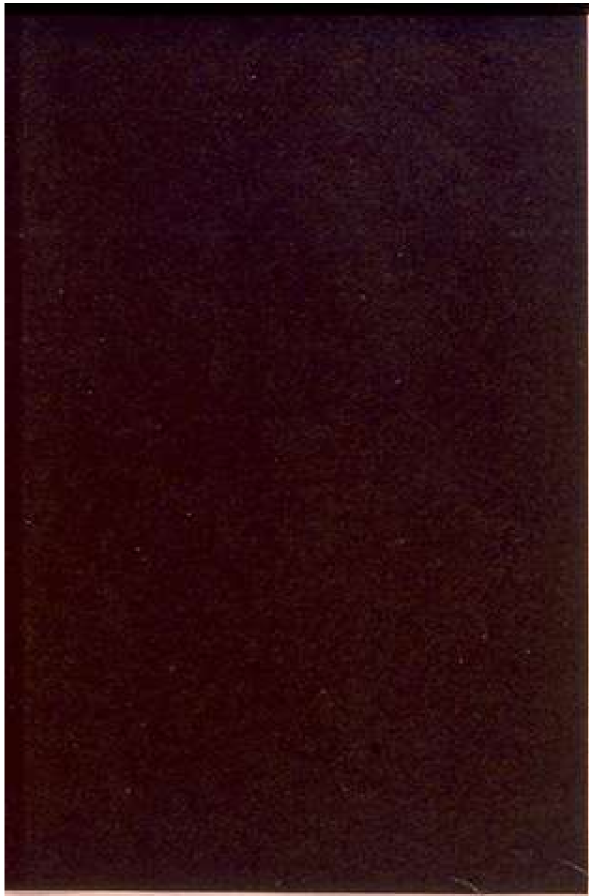
Displayed Image
820550

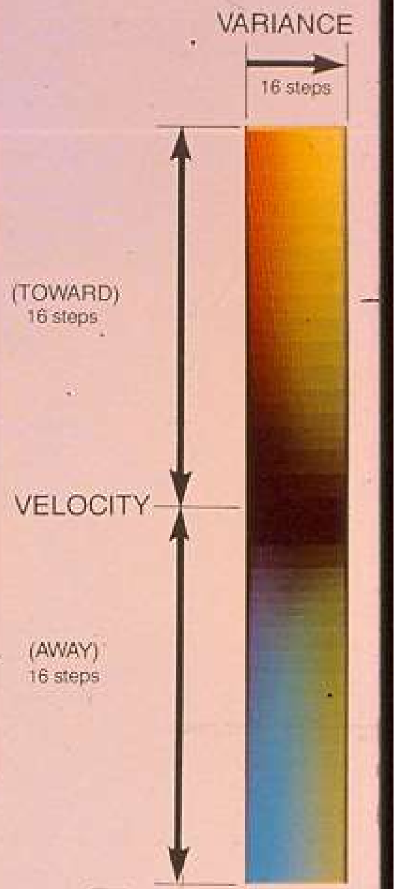



TOSHIBA

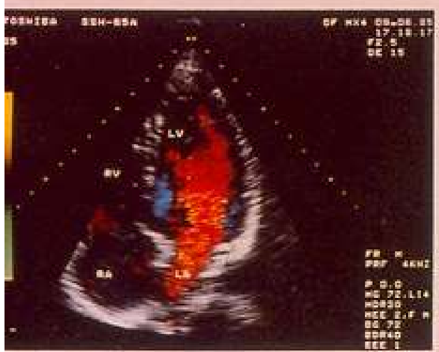


Oszillator
8 MHz
Mixer
0.001 MHz
= 1 kHz
7,999 MHz
Gefäß
Haut
12 cm/sec

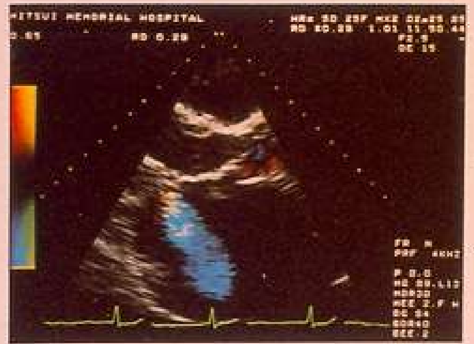




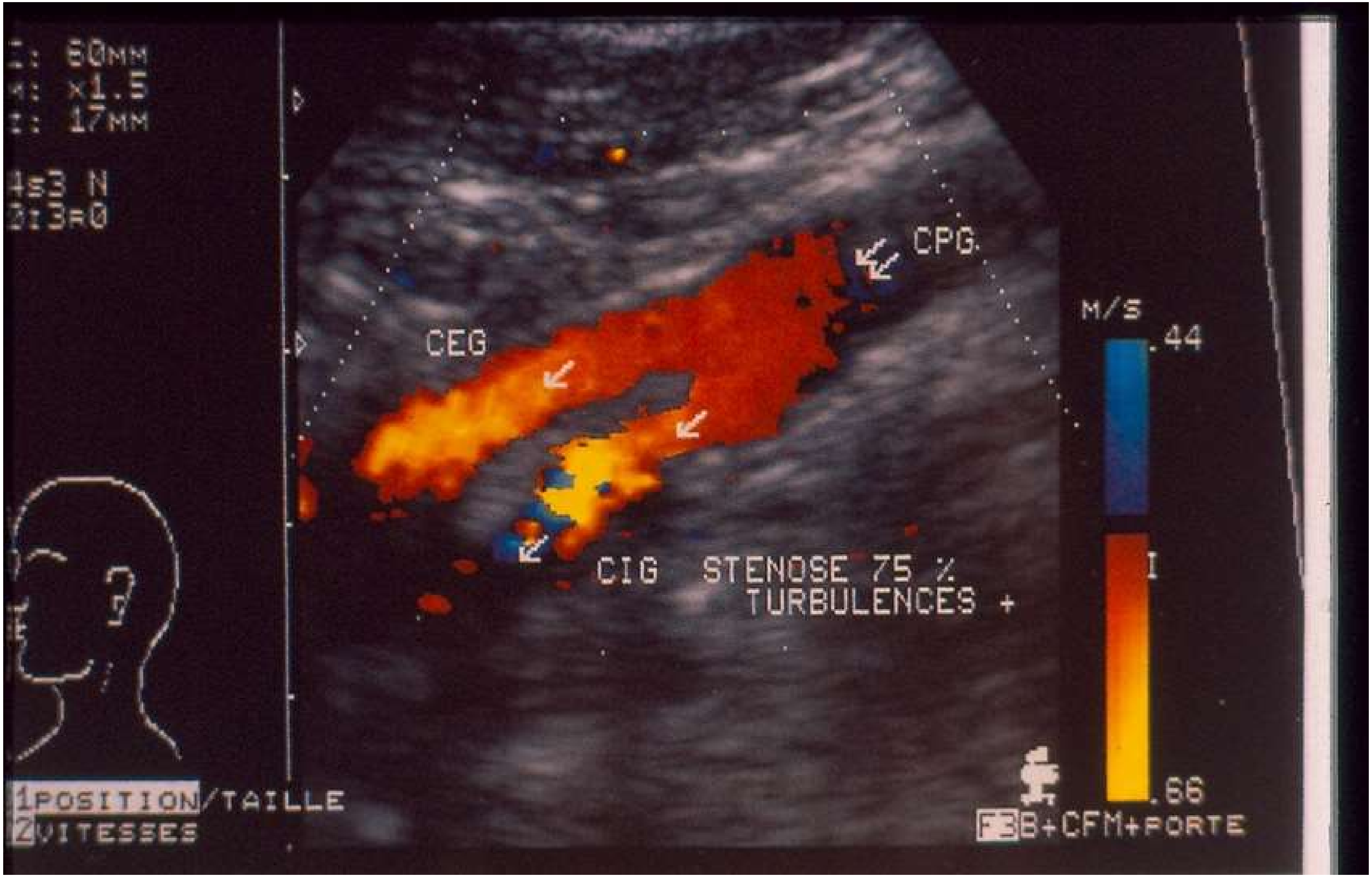
ood flow displays to that of a normal
oss sectional image.



ical 4-chamber View

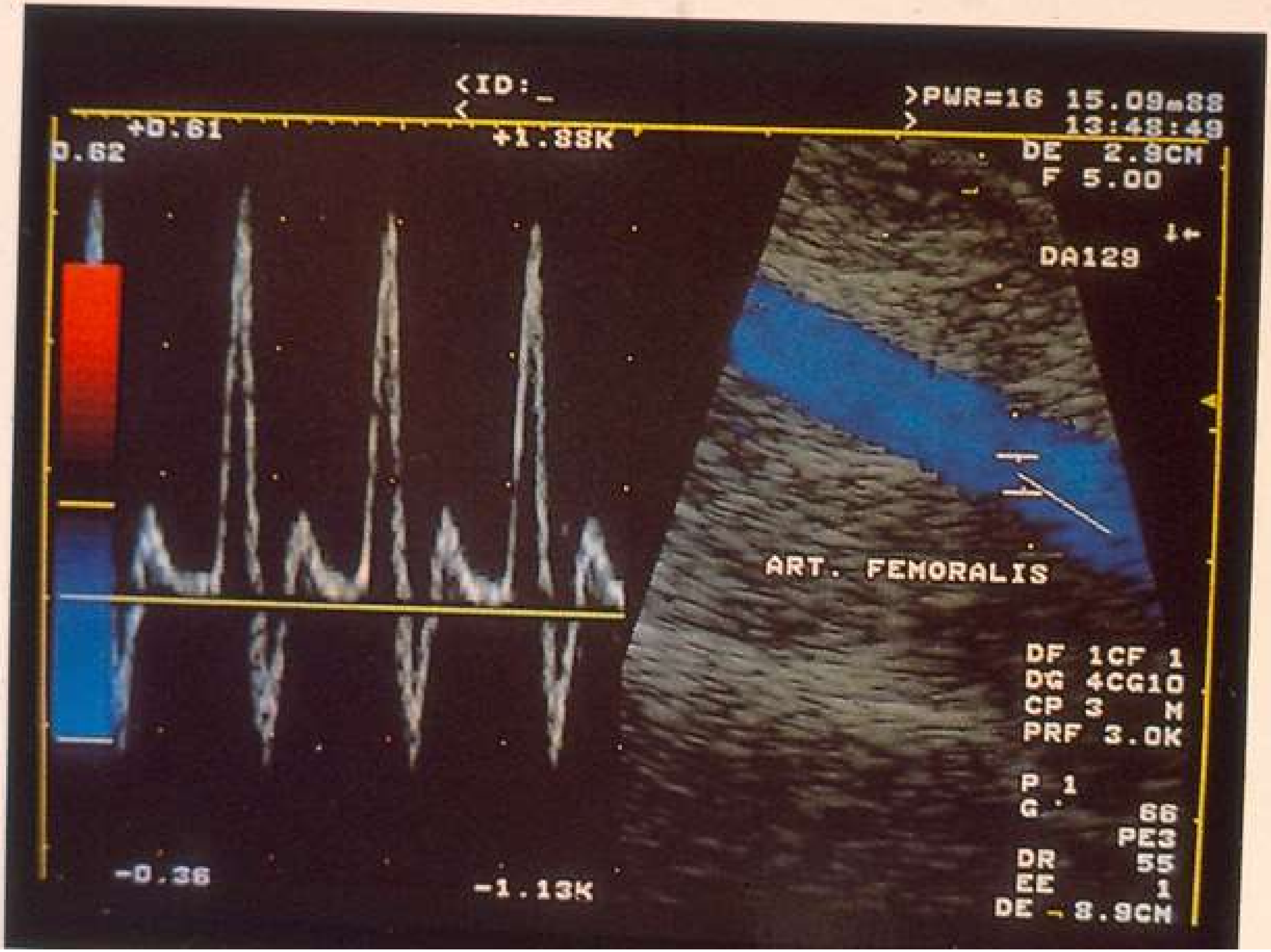


Mitral Regurgitation

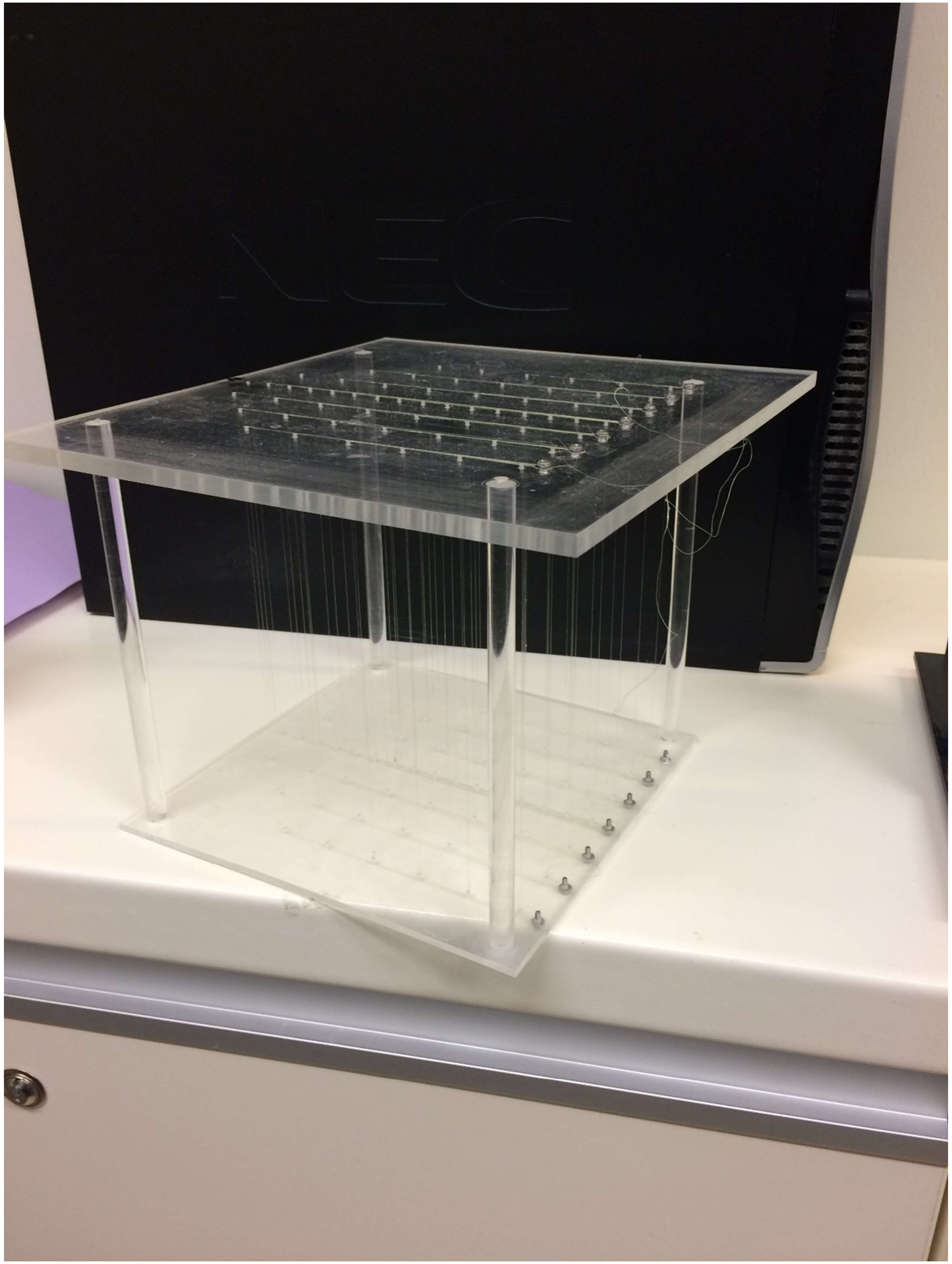


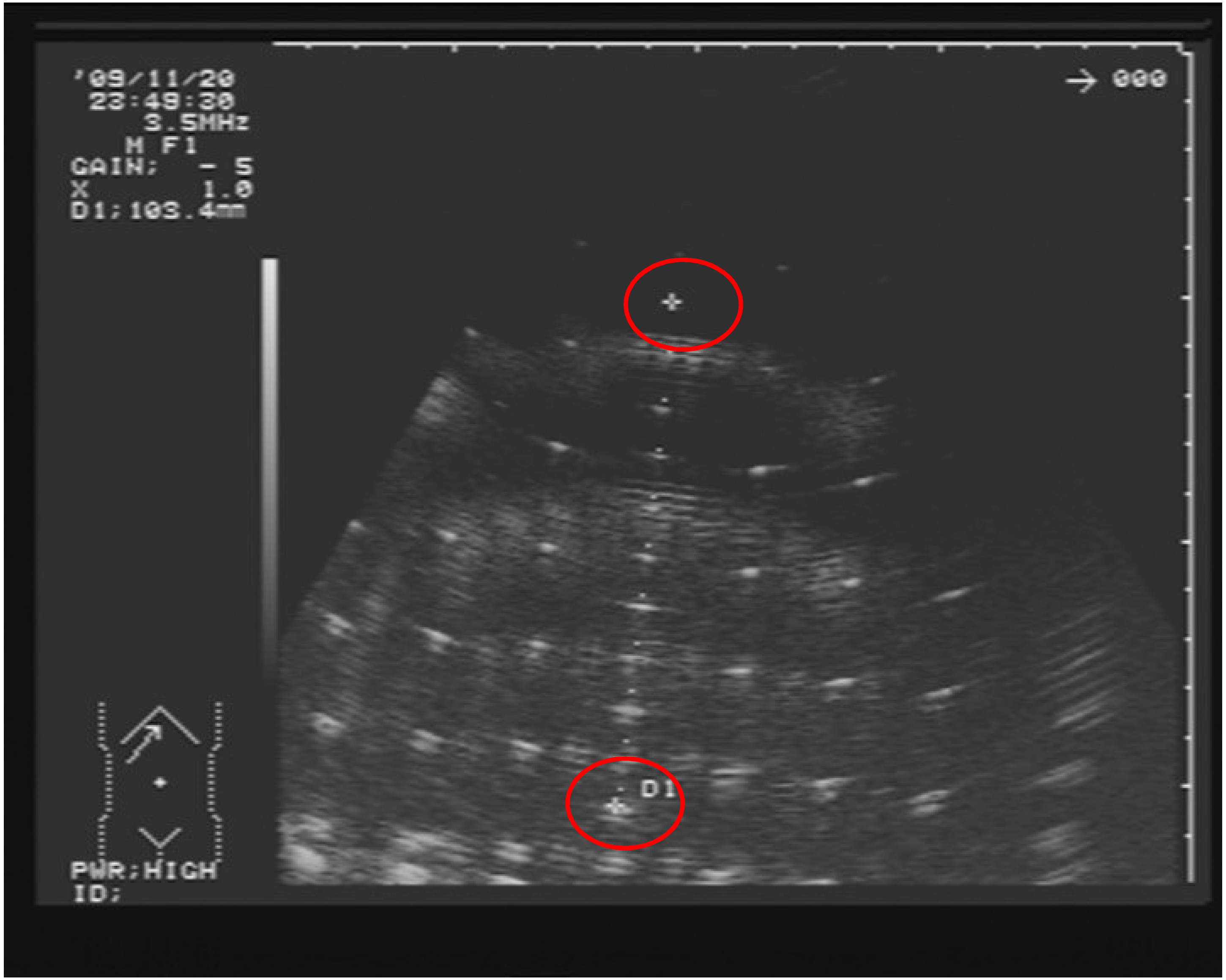
CEG
CPG
CIG
STENOSE 75 %
TURBULENCES +
M/S
.44
.66
1POSITION/TAILLE
2VITESSES
F3B+CFM+PORTE

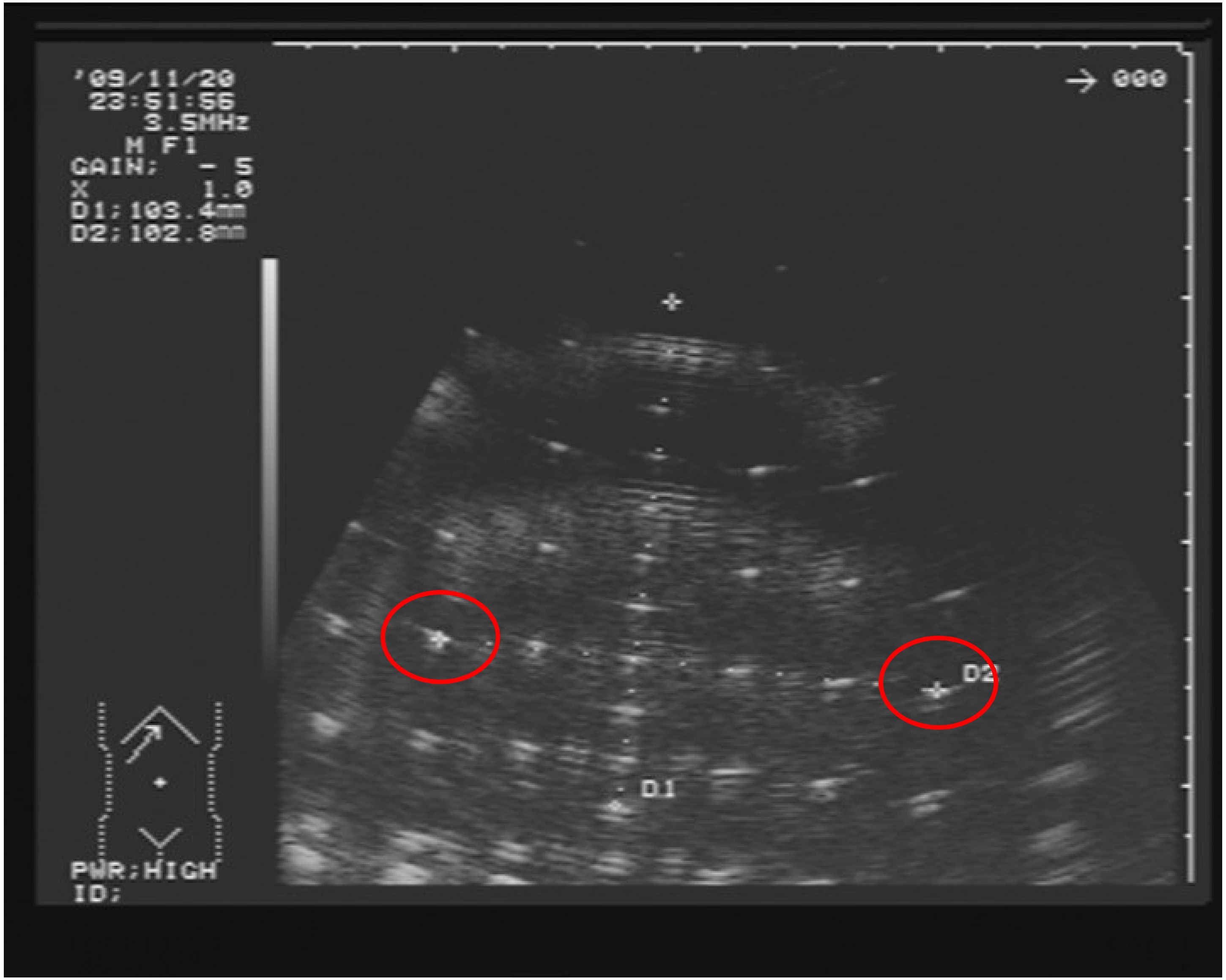
20. Femoral artery



16. Fetal heart

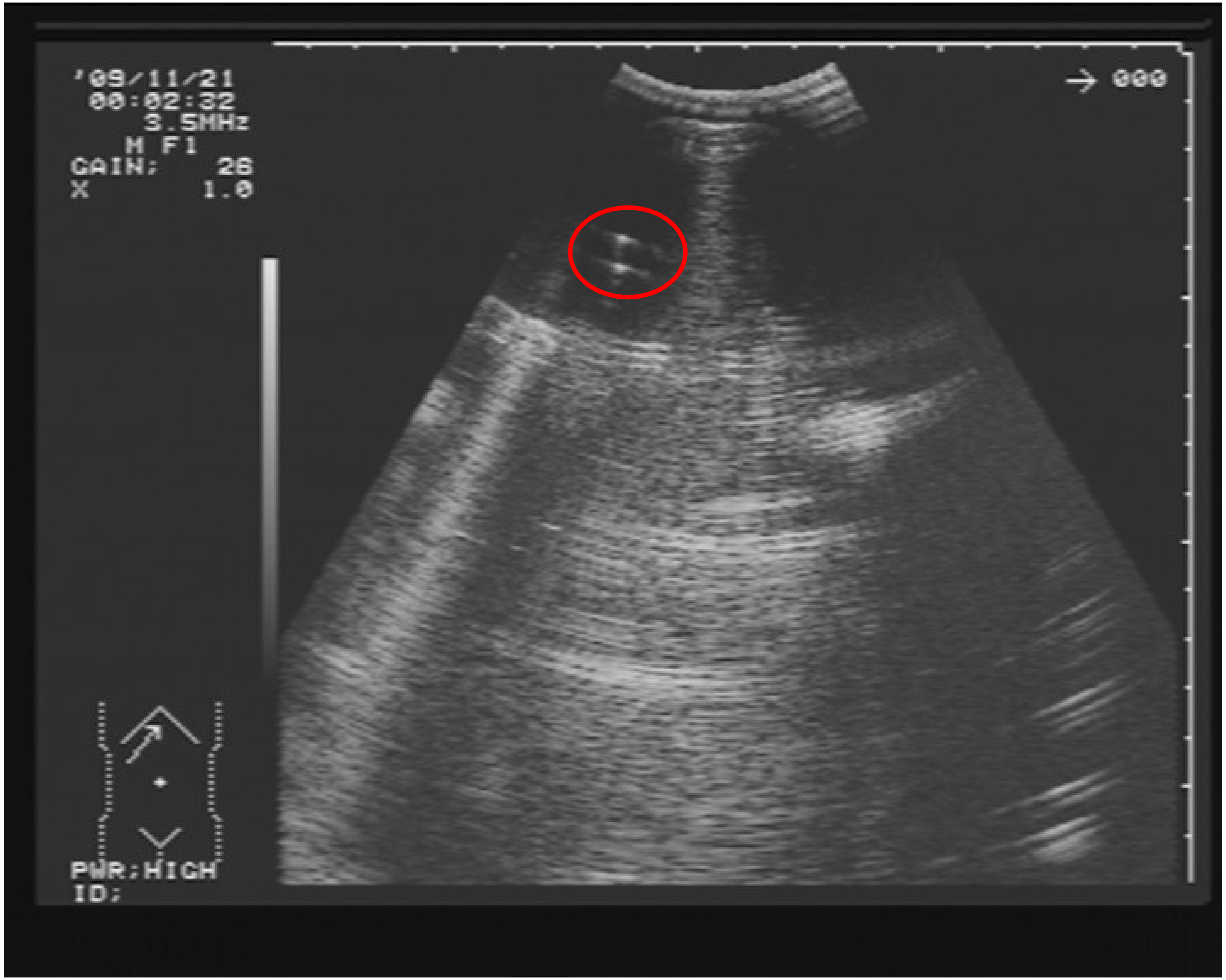

NEC


'09/11/20
23:49:30
3.5MHz
M F1
GAIN; - 5
X 1.0
D1;103.4mm
→ 000
D1
PWR;HIGH
ID;


'09/11/20
23:51:56
3.5MHz
M F1
GAIN; - 5
X 1.0
D1;103.4mm
D2;102.8mm
→ 000
D1
D2
PWR;HIGH
ID;

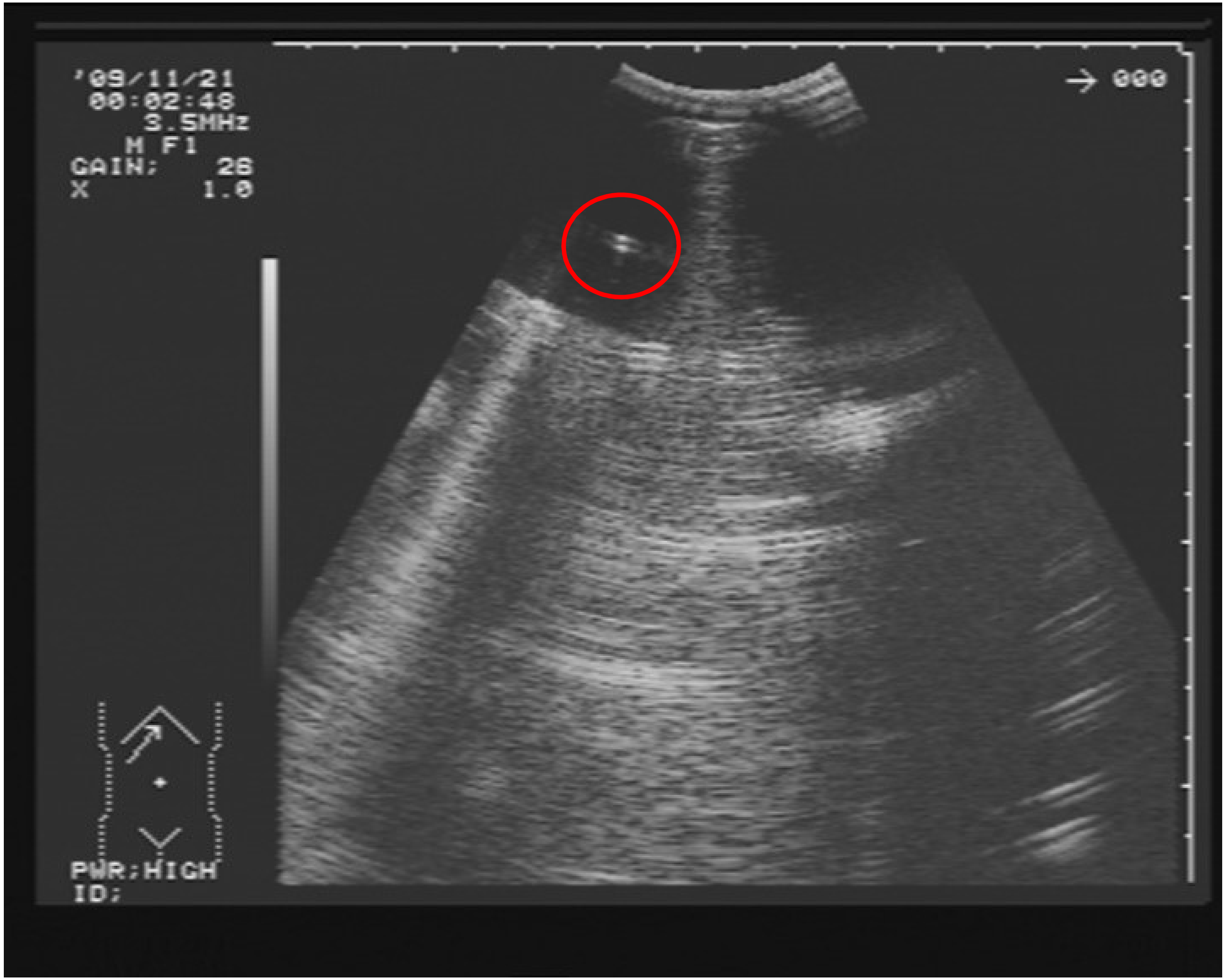

mm/inch
0.1935
in
OFF
ON
ZERO
100

3.5 MHz
axial direction, close to the transducer

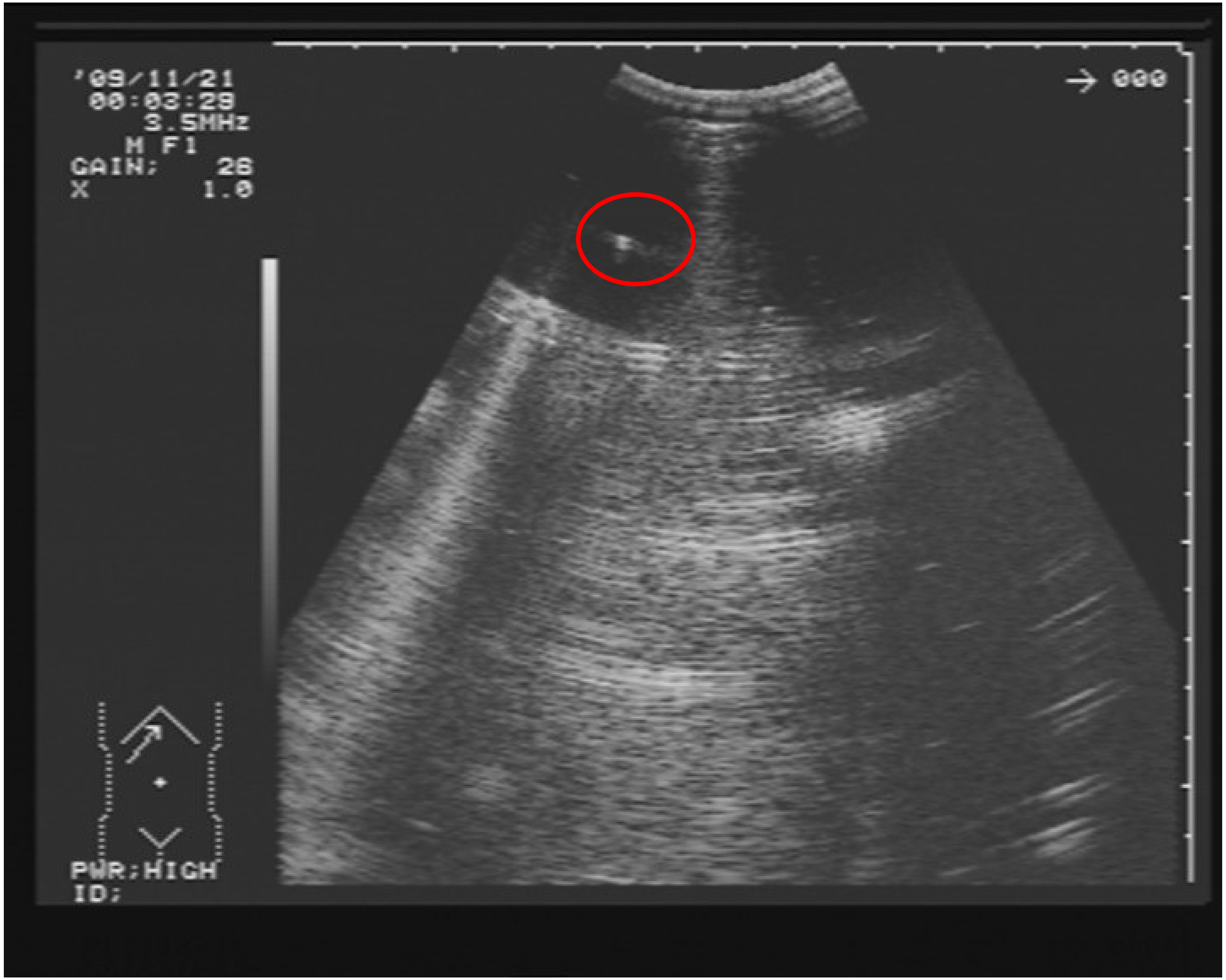


3.5 MHz

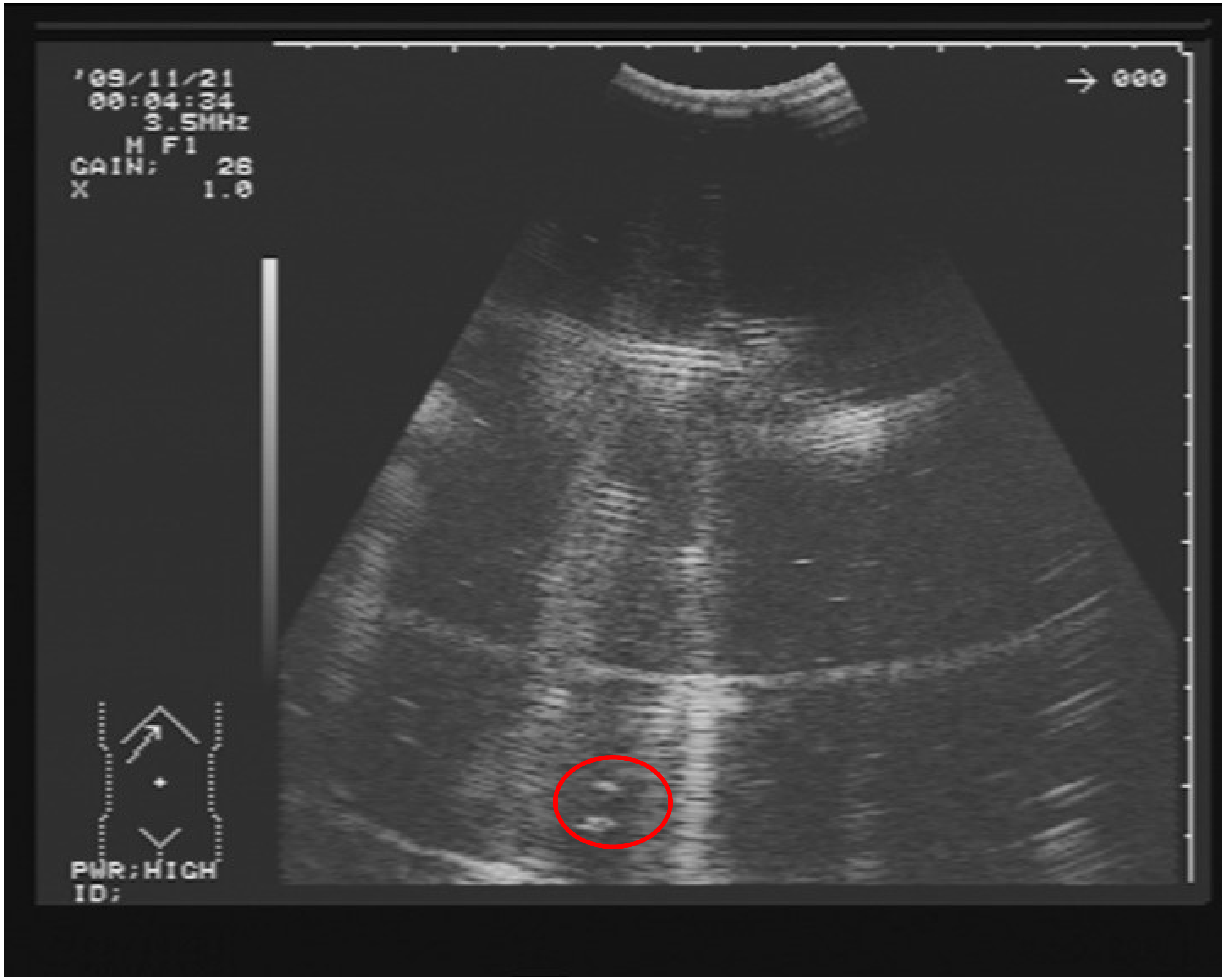
axial direction, close to the transducer



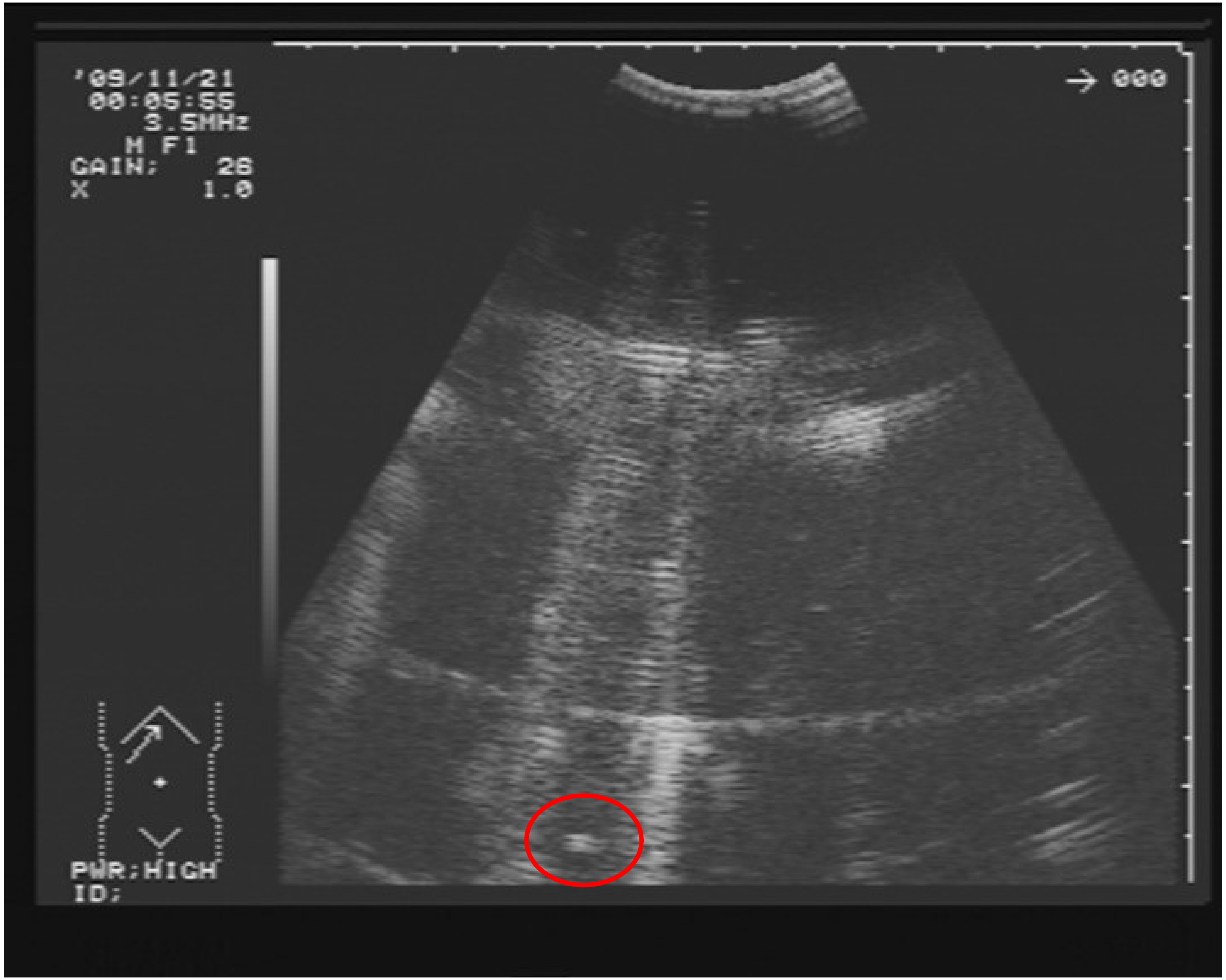
3.5 MHz
axial direction, close to the transducer
0.43 mm



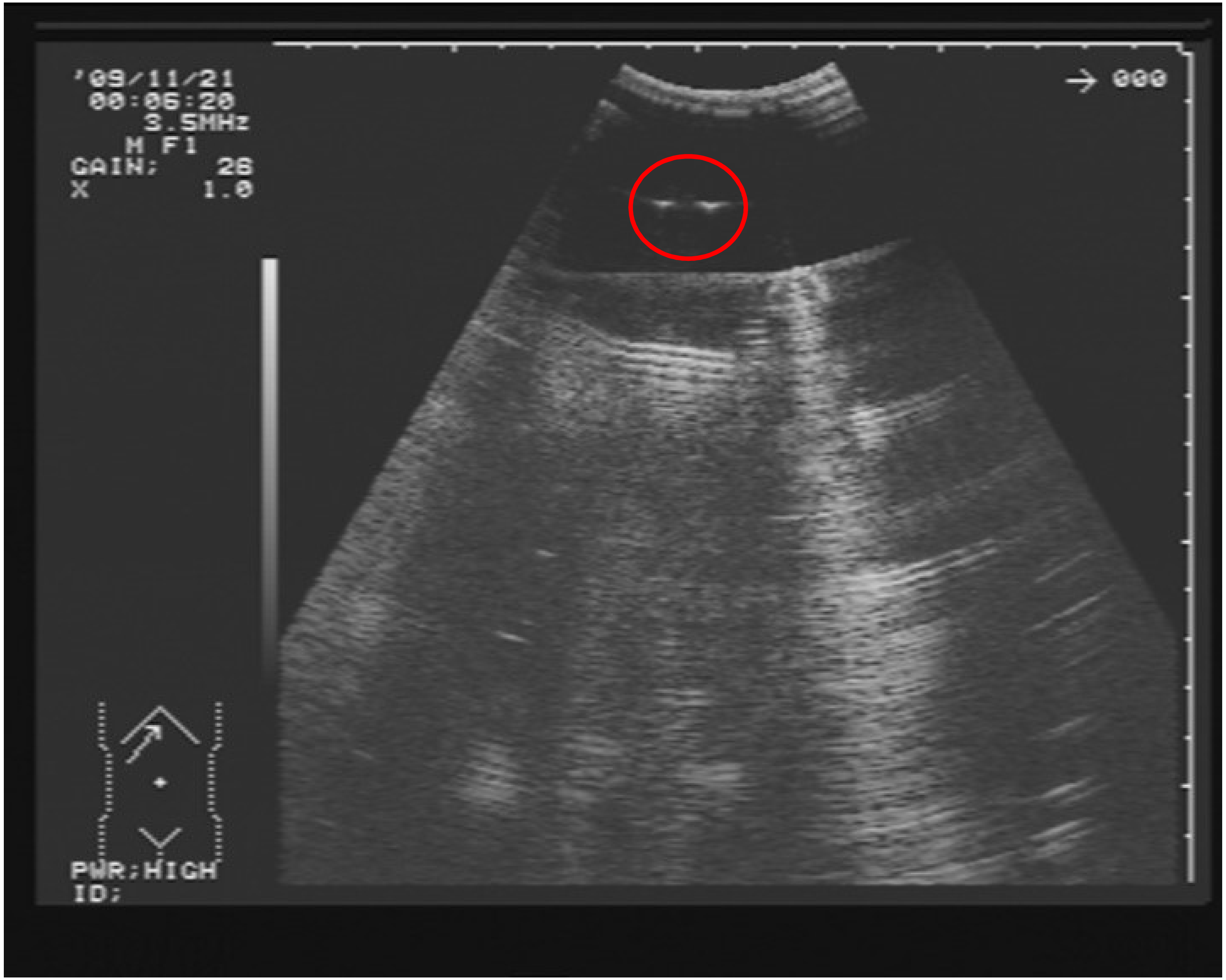
3.5 MHz
axial direction, far from the transducer



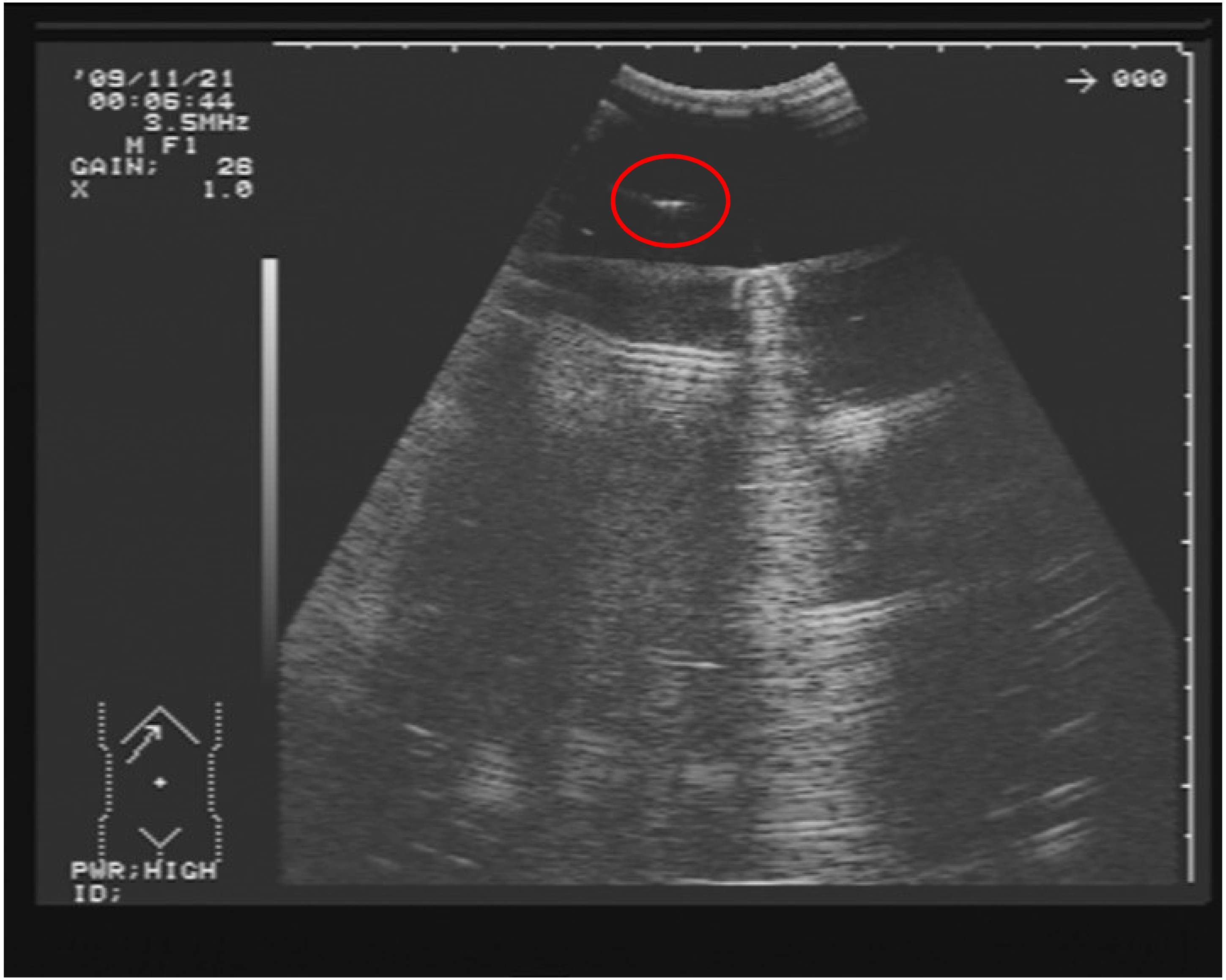
3.5 MHz
axial direction, far from the transducer
0.51 mm



3.5 MHz
lateral direction, close to the transducer

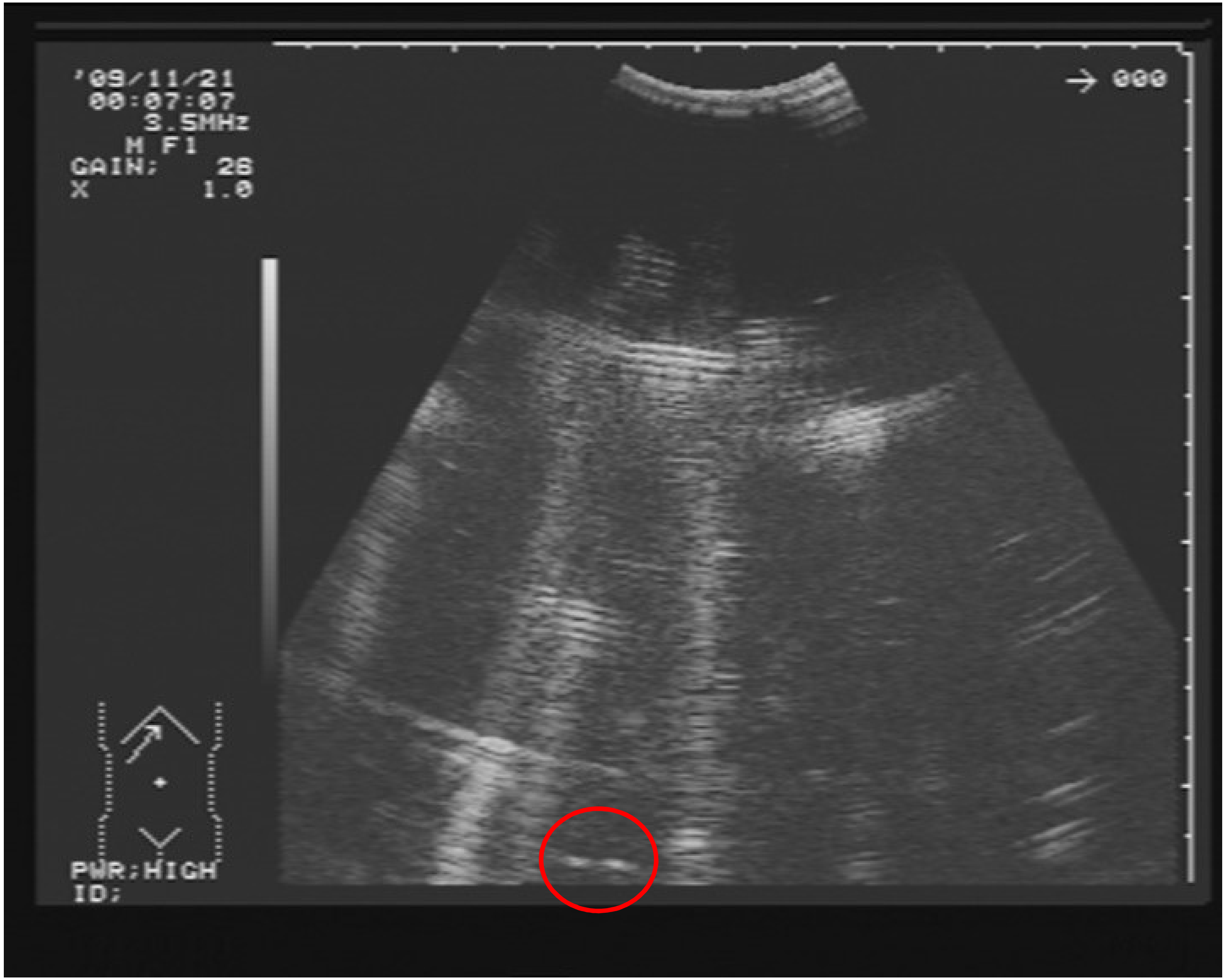


3.5 MHz
lateral direction, close to the transducer
0.99 mm



3.5 MHz

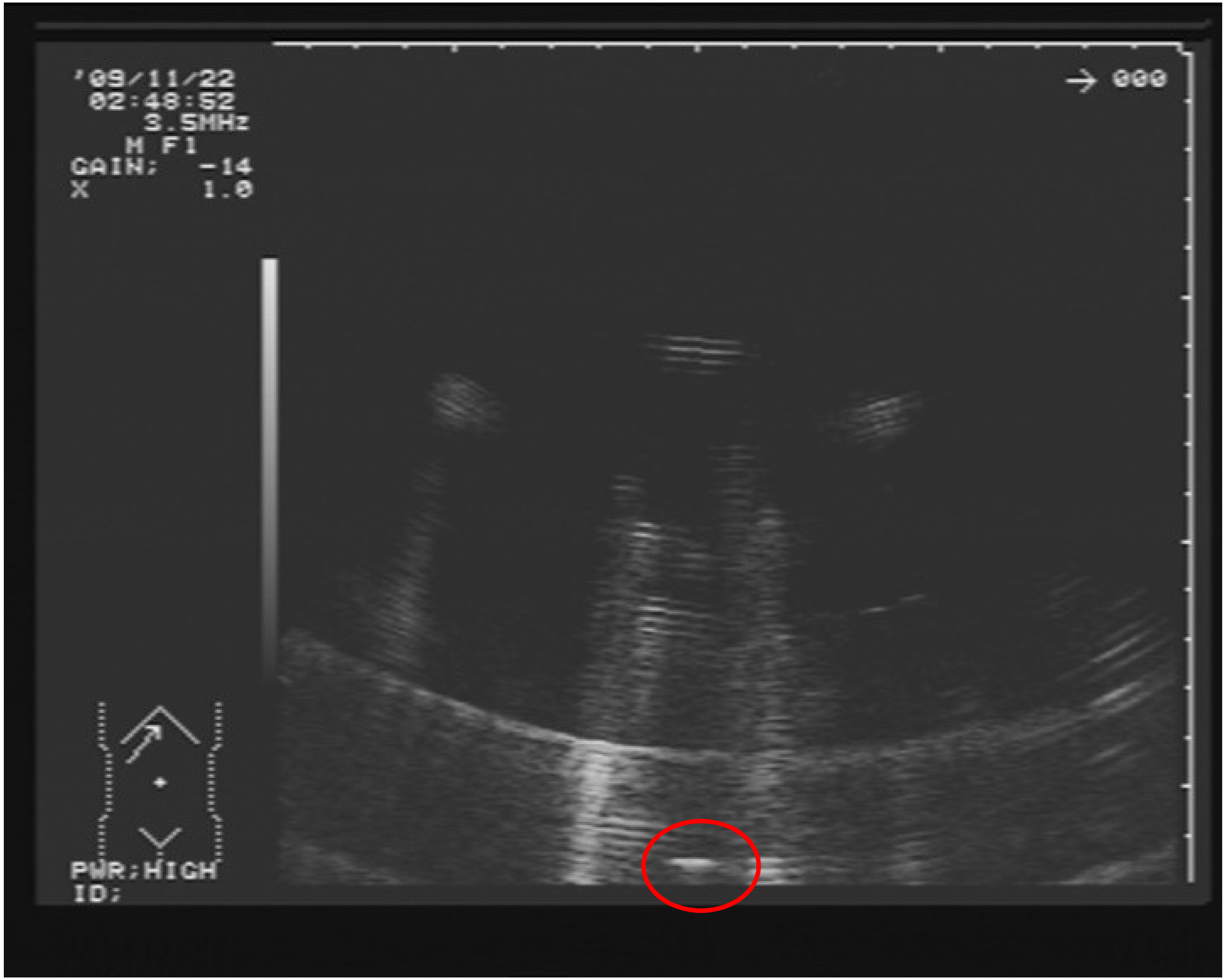
lateral direction, far from the transducer



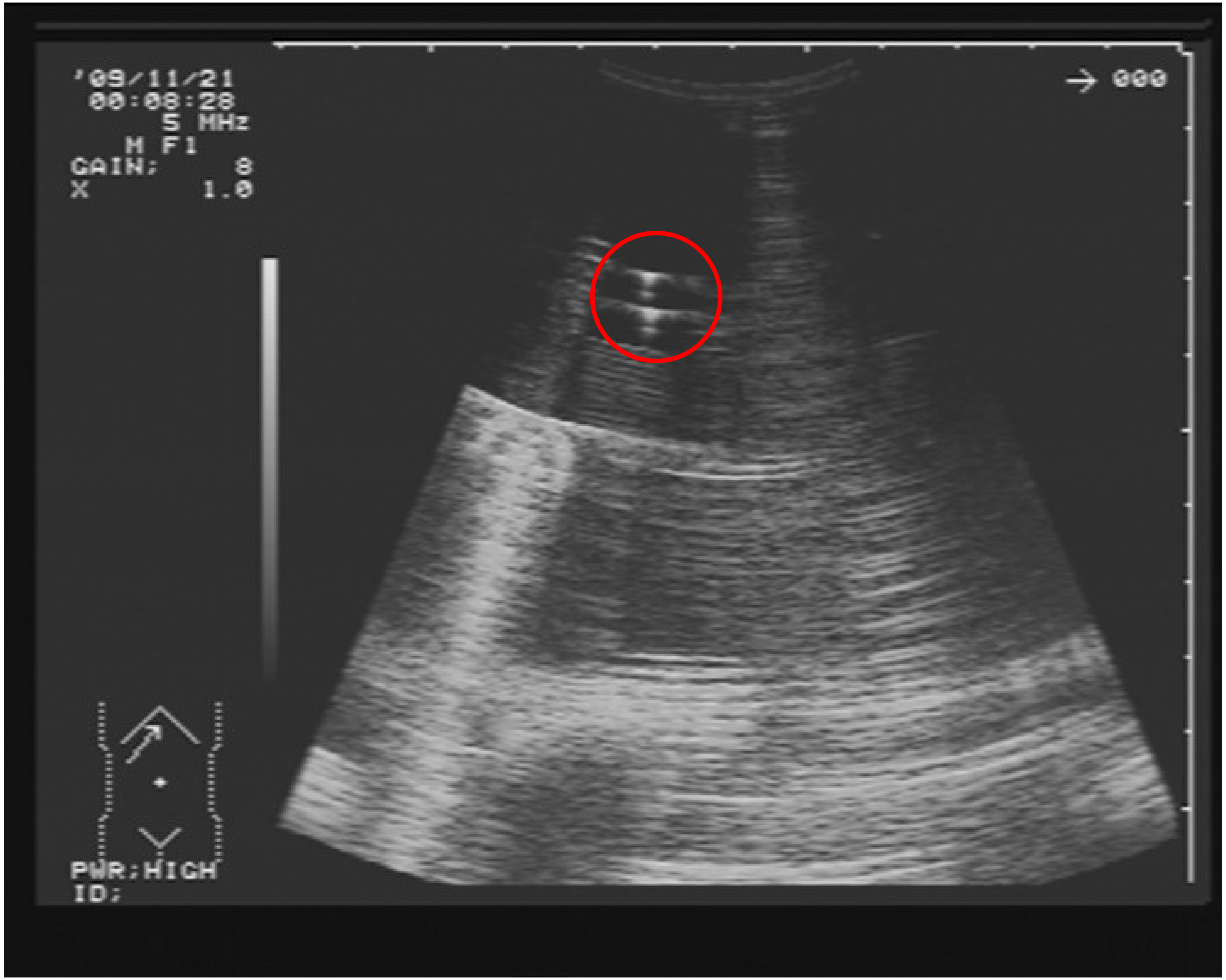
3.5 MHz

lateral direction, far from the transducer

1.79 mm



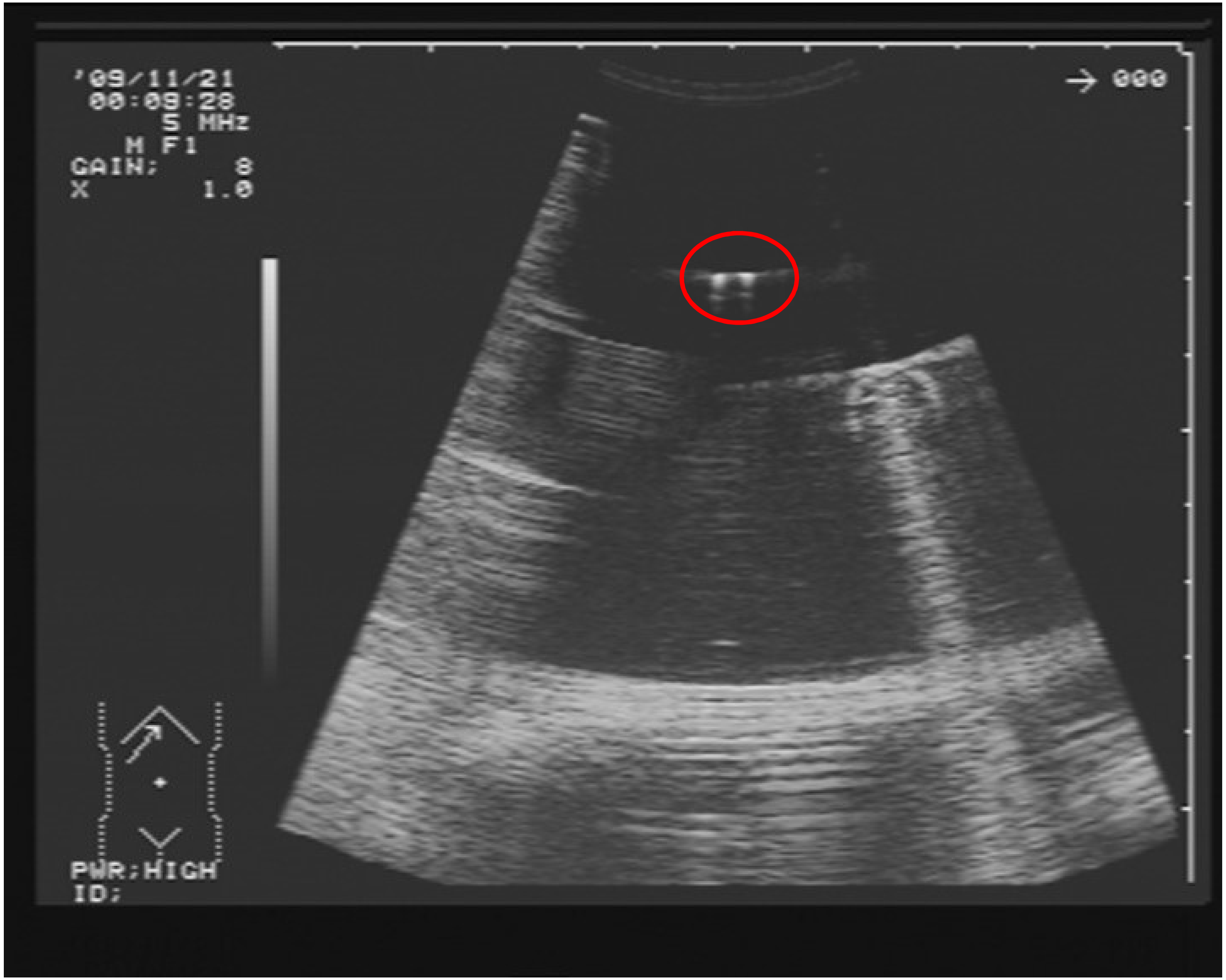
5 MHz
axial direction, close to the transducer



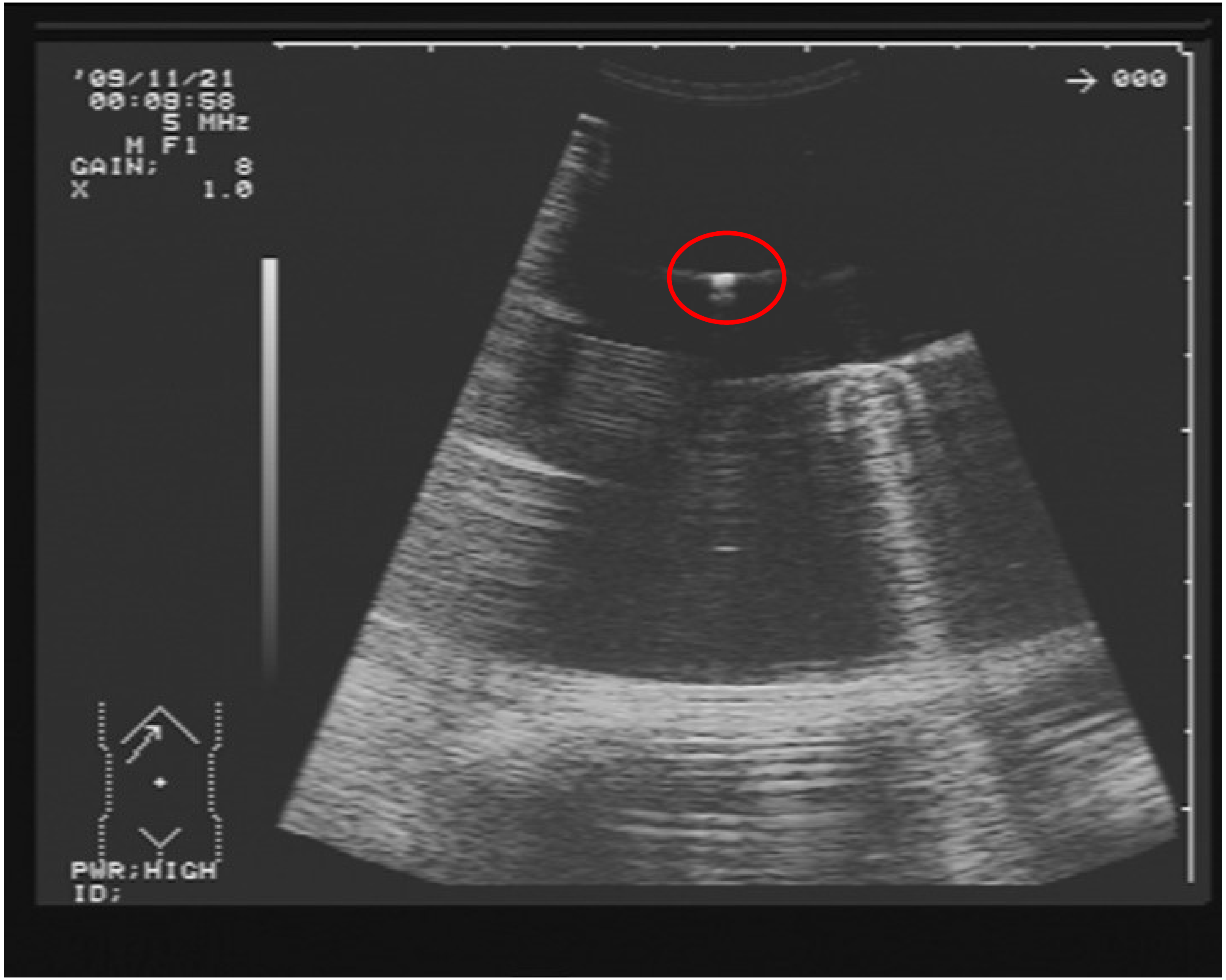
5 MHz
axial direction, close to the transducer
0.23 mm

5 MHz

lateral direction, close to the transducer

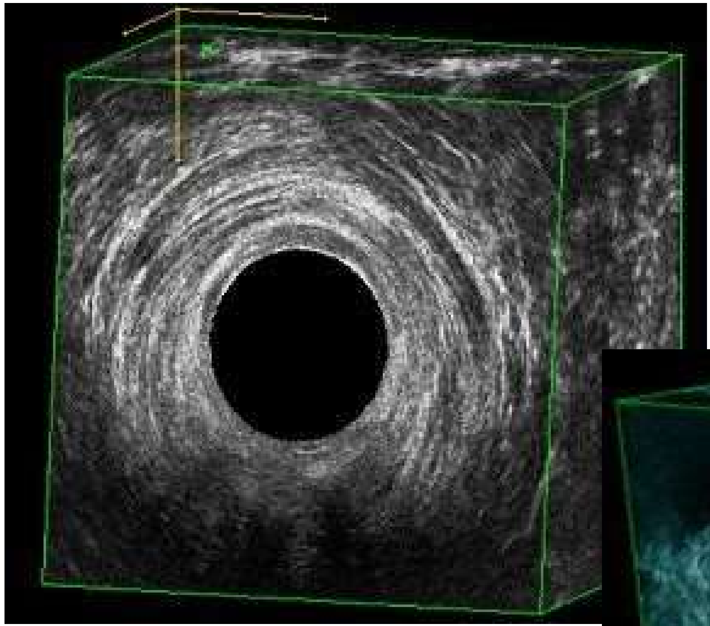


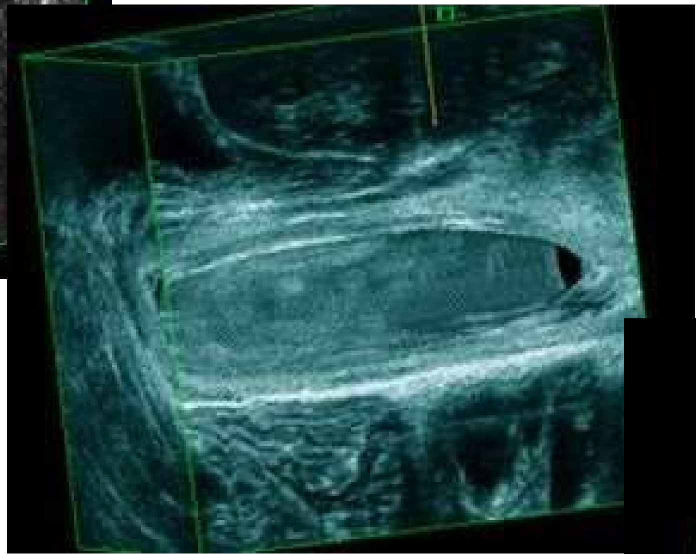
5 MHz
lateral direction, close to the transducer
0.41 mm

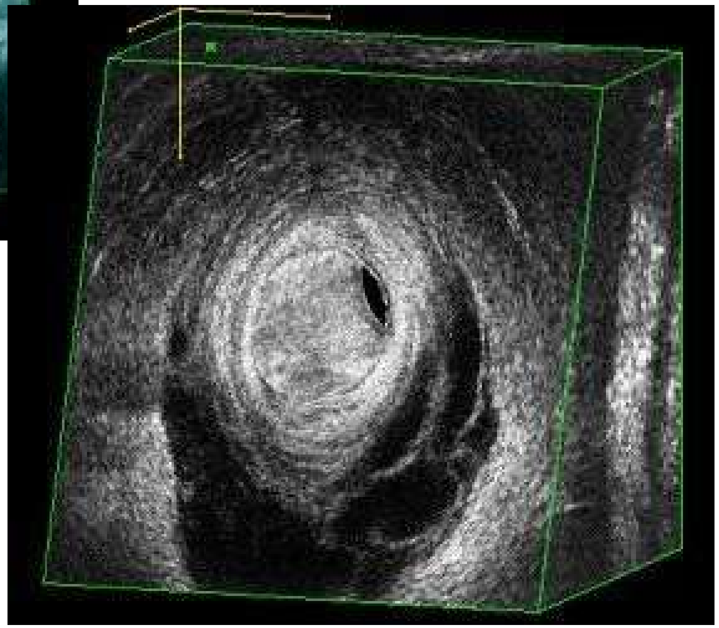


Endosonography

3D endosonography







Sonoelastography

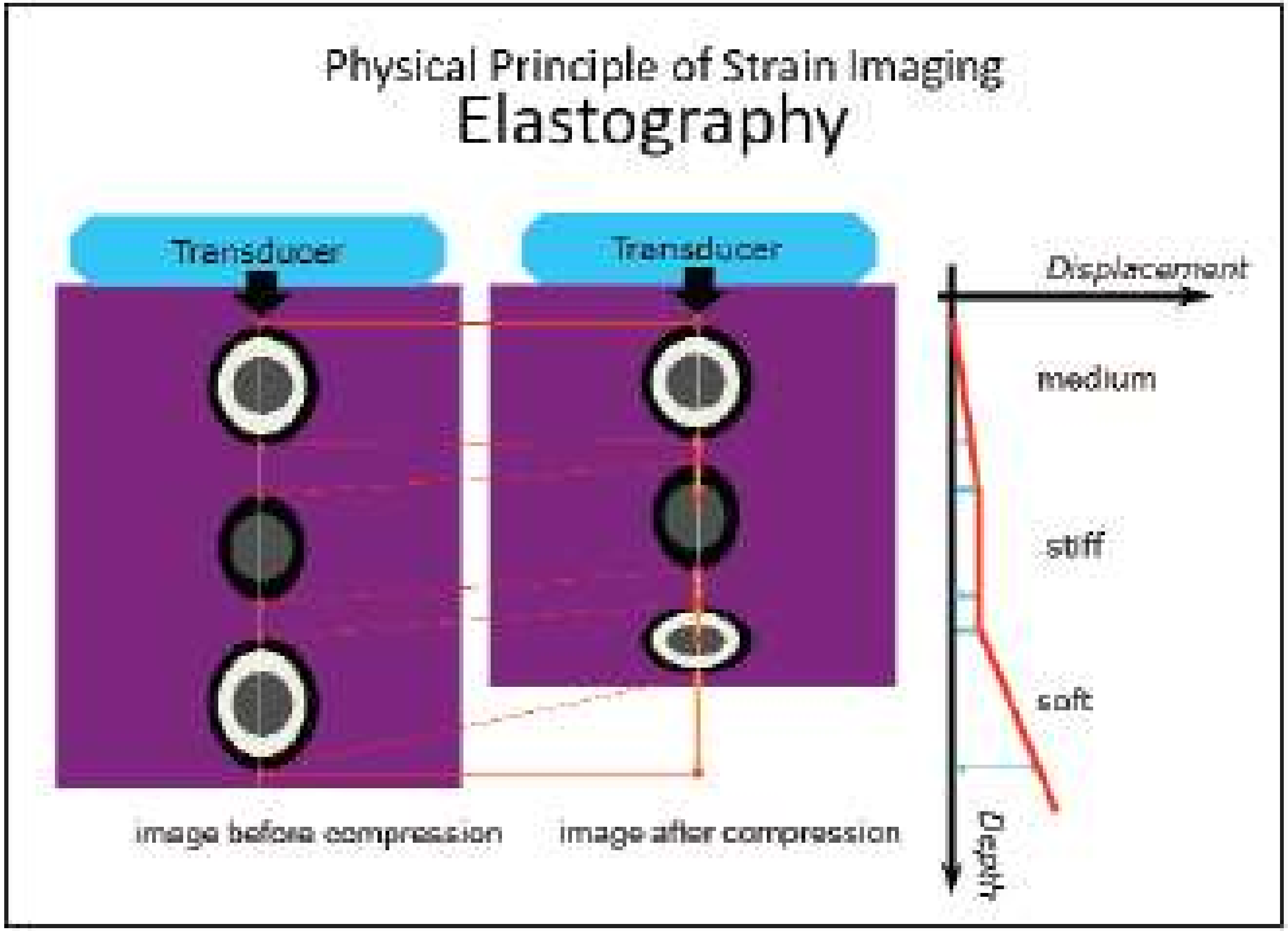
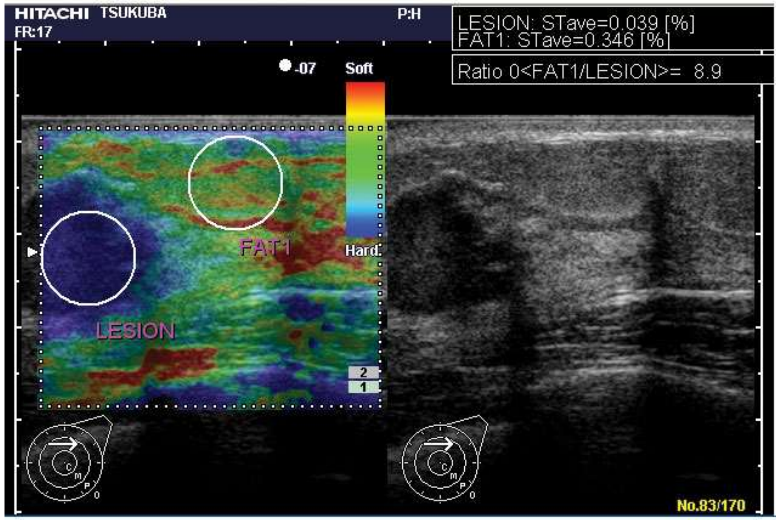


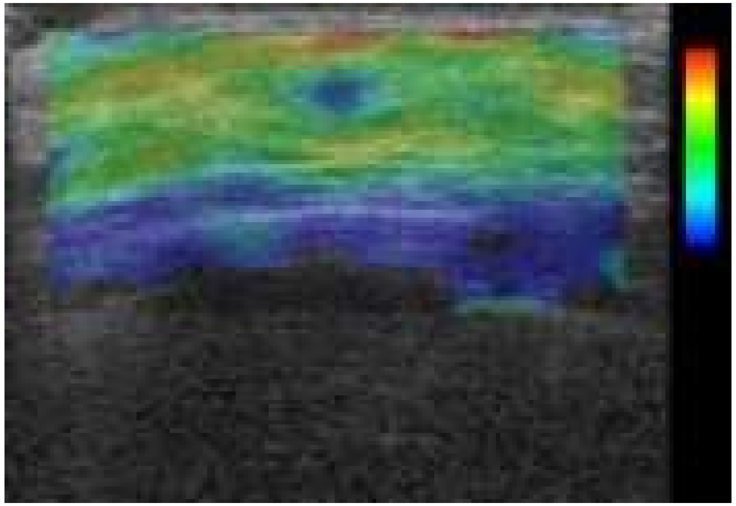
FIGURE 1. Displacement due to compression varies according to tissue stiffness. Displacement in soft tissue is high, whereas stiff tissue shows no or very little displacement.

Sonoelastography (brest)

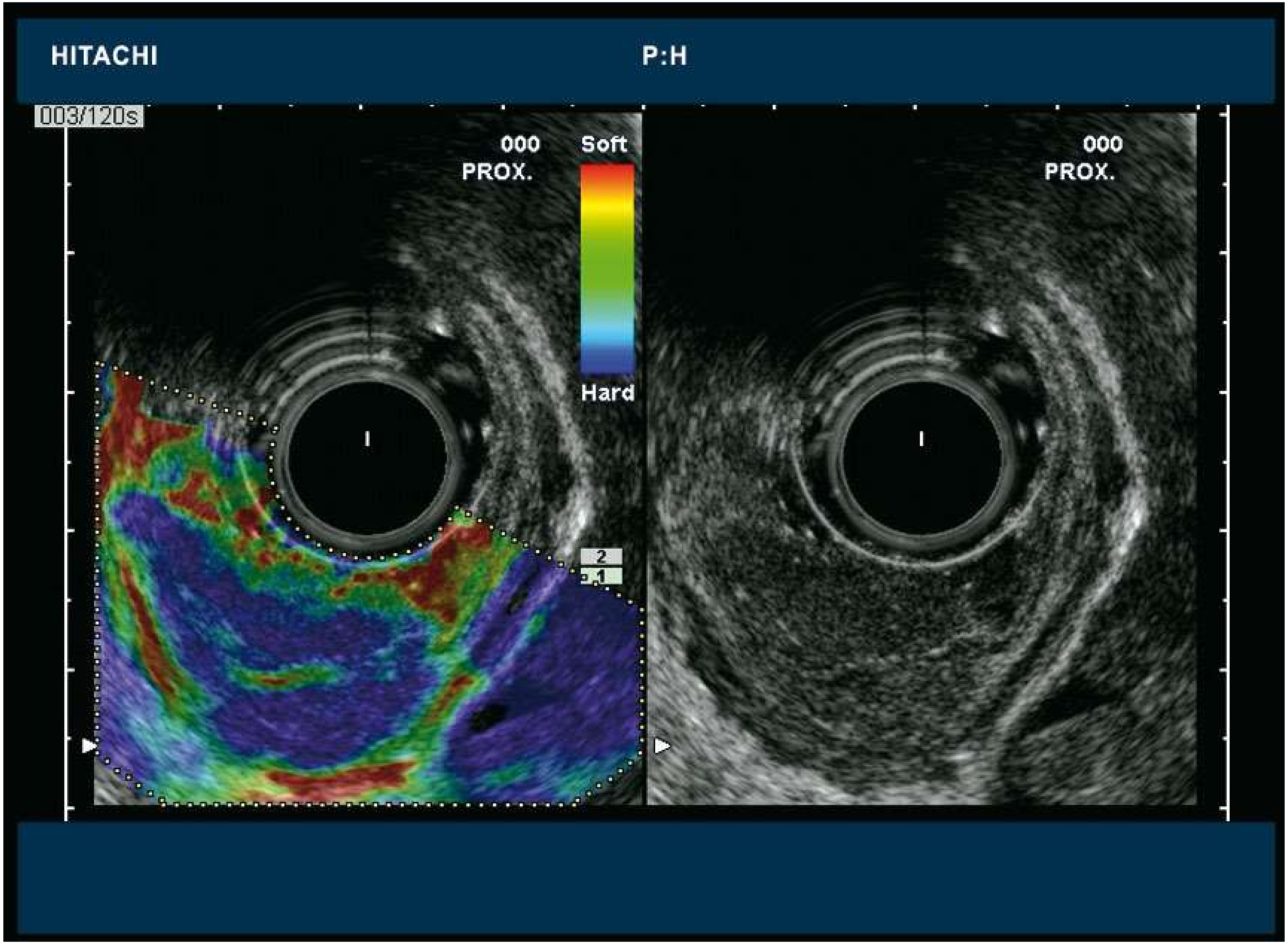
Figure 4. IDC Using Sonoelastography



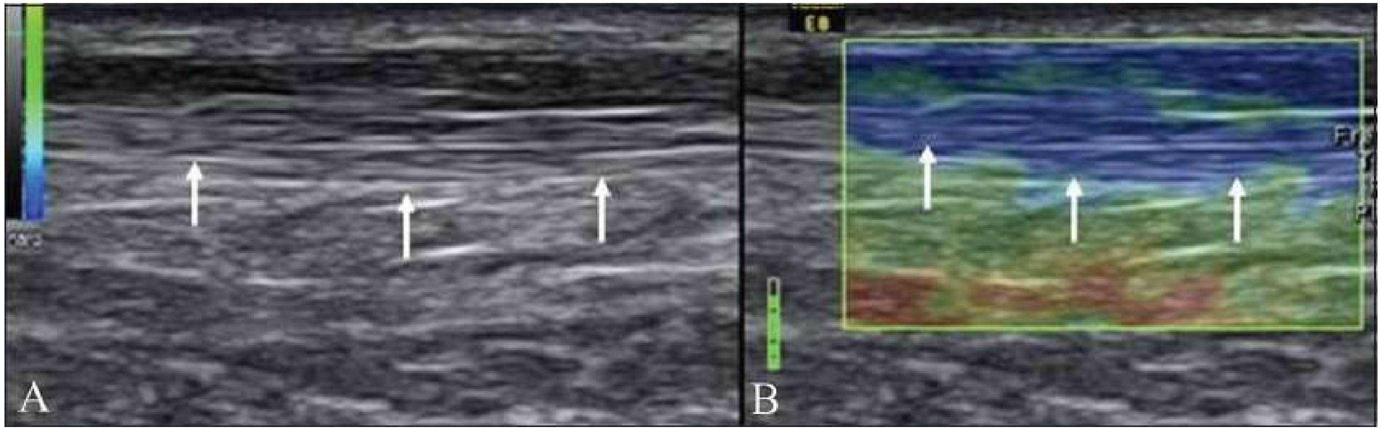
Blue indicates a lesion with no tissue strain (hard) with an FLR of 8.9, highly suggestive of a malignancy.
FLR = fat-to-lesion ratio; IDC = invasive ductal carcinoma.
Image courtesy of Hitachi Medical Systems.



Sonoelastography (rectal cancer)

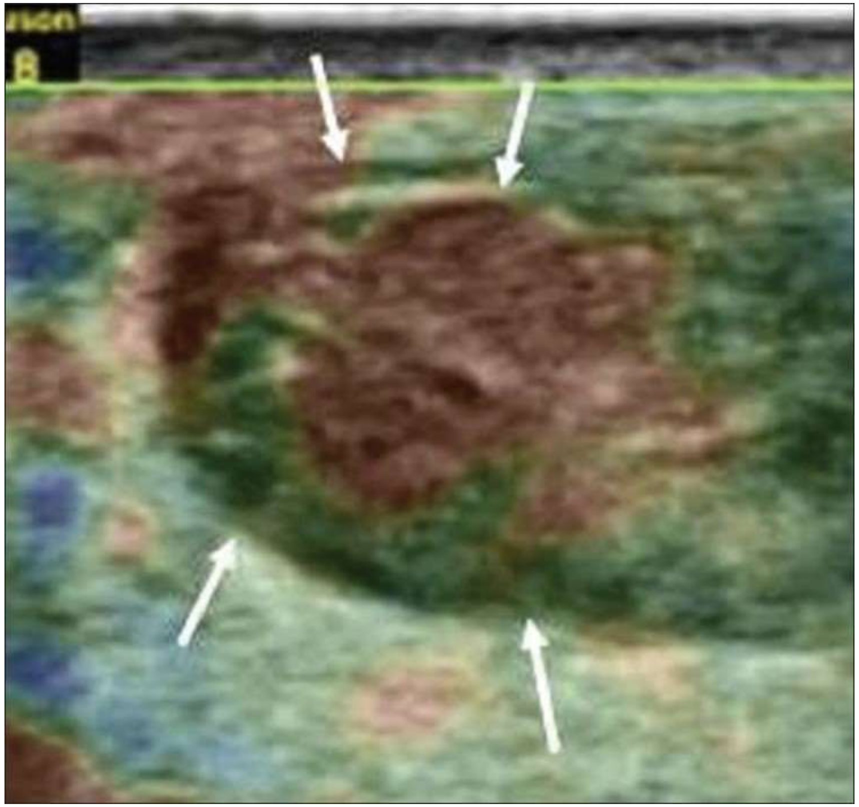


Sonoelastography (Achilles-tendon)

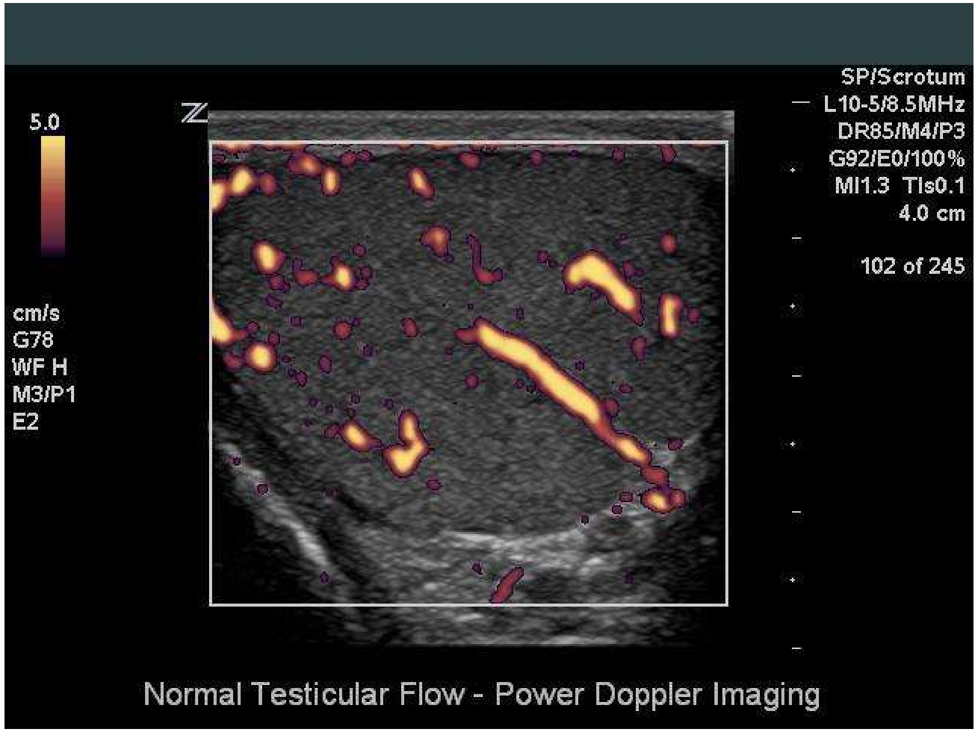


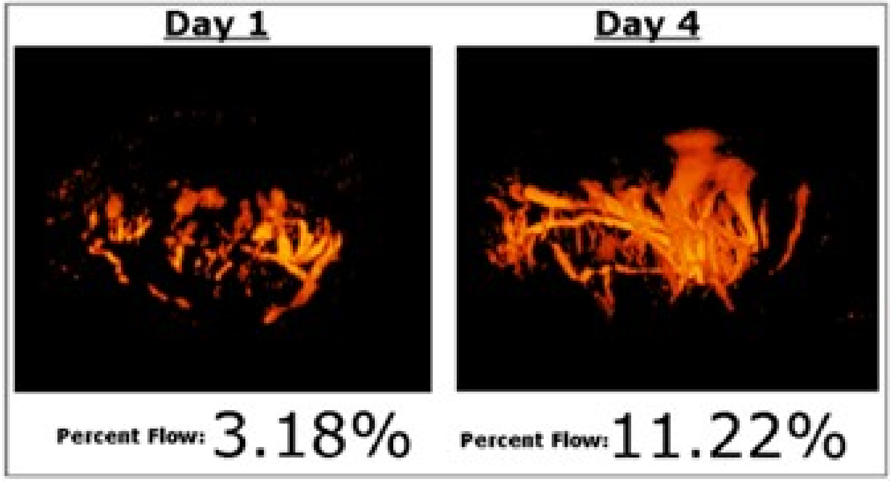
normal

tendinitis

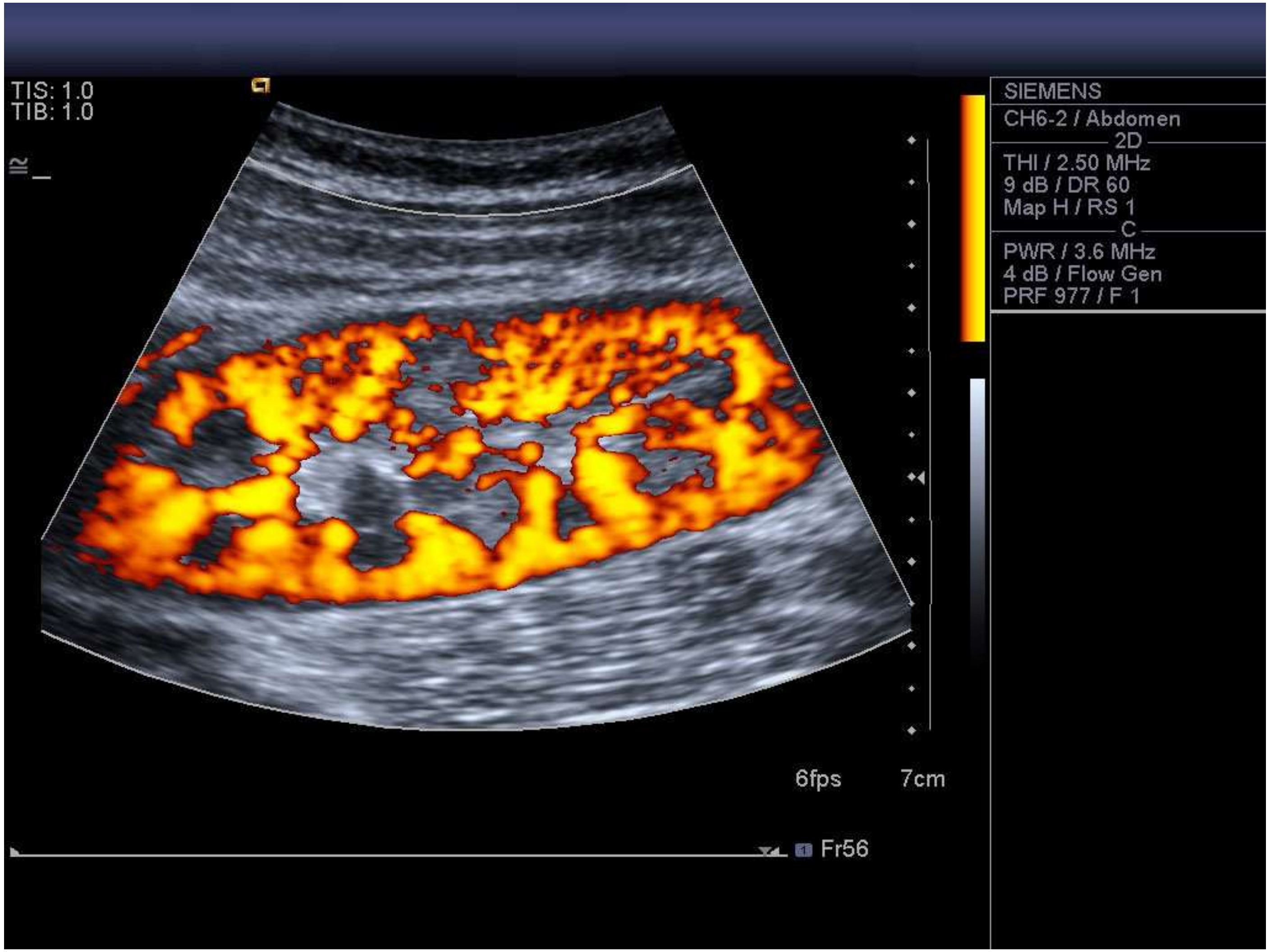


Power Doppler Imaging (PDI)

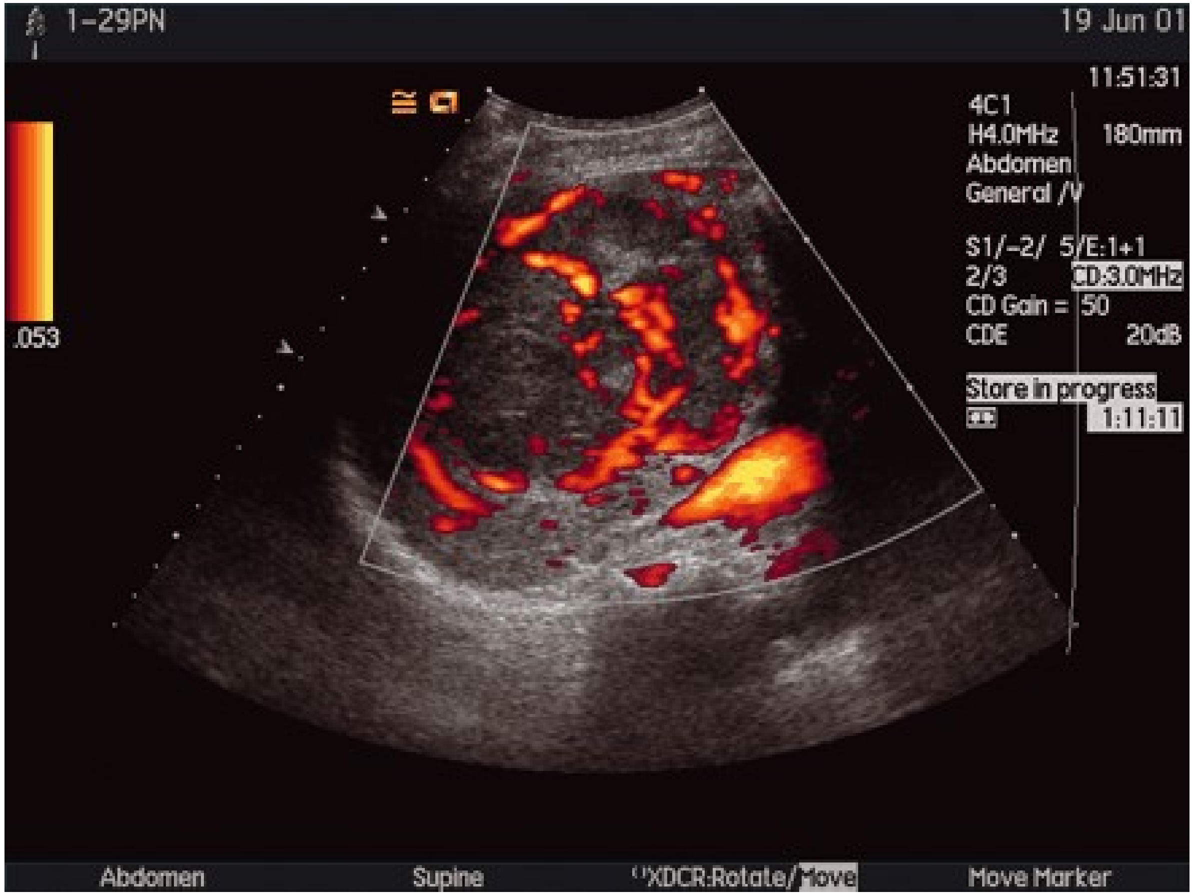




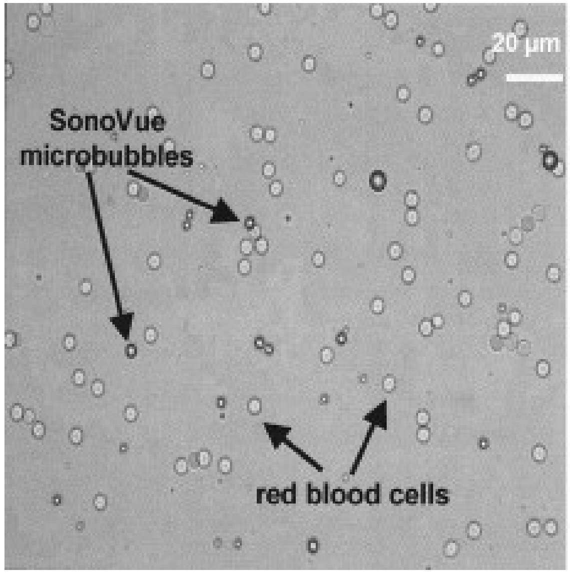
Power Doppler Imaging (PDI - kidney)

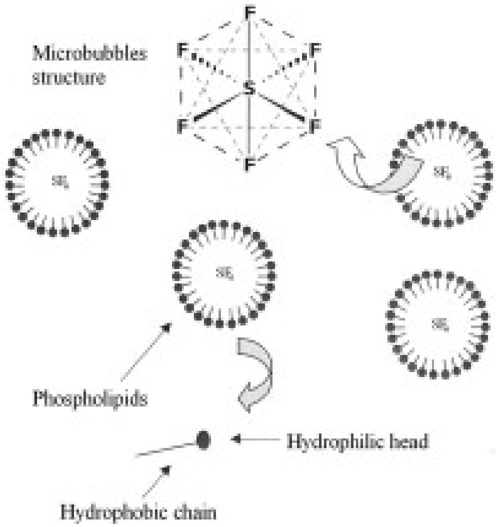


Power Doppler Imaging (PDI – hepatocellular cancer)



Ultrasound contrast materials





Ultrasound contrast materials
(air microbubbles in liposomes or in peptides)