FAKULTNÍ NEMOCNICE BRNO

FACULTAS MEDICA UNIVERSITATIS MASARYKIANAE BRUNENSIS

Ultrasound

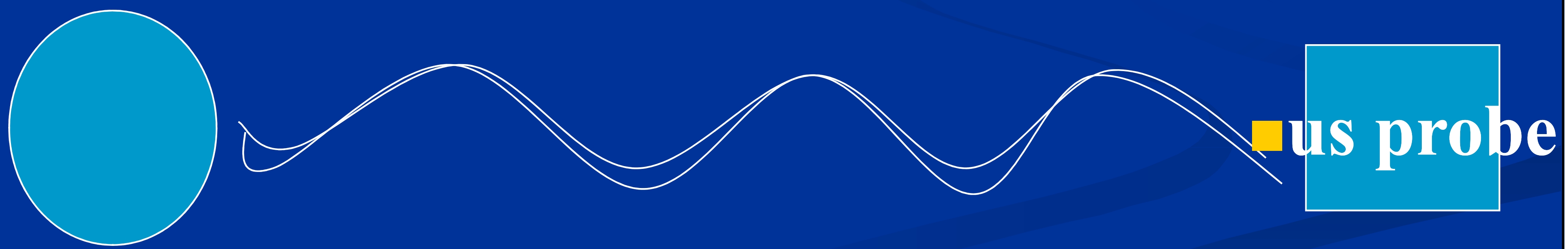
1) CEUS (contrast enhanced ultrasound)
2) Elastography
3) Navigation systems

CEUS Principle

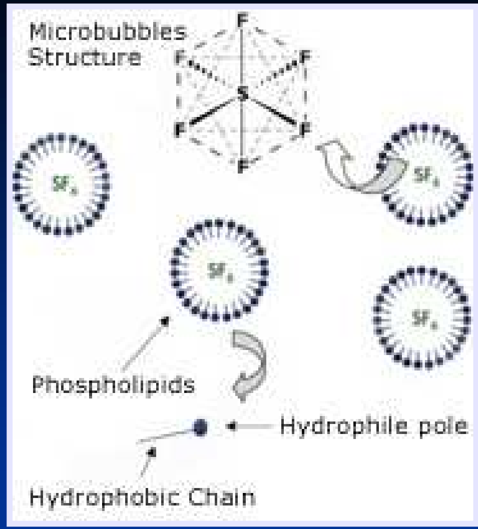
Gas bubbles reflect back ultrasound waves

They are strictly intravascular, they do not penetrate into the extravascular space.

They rupture and gas from them is excreted through the lungs



SonoVue®



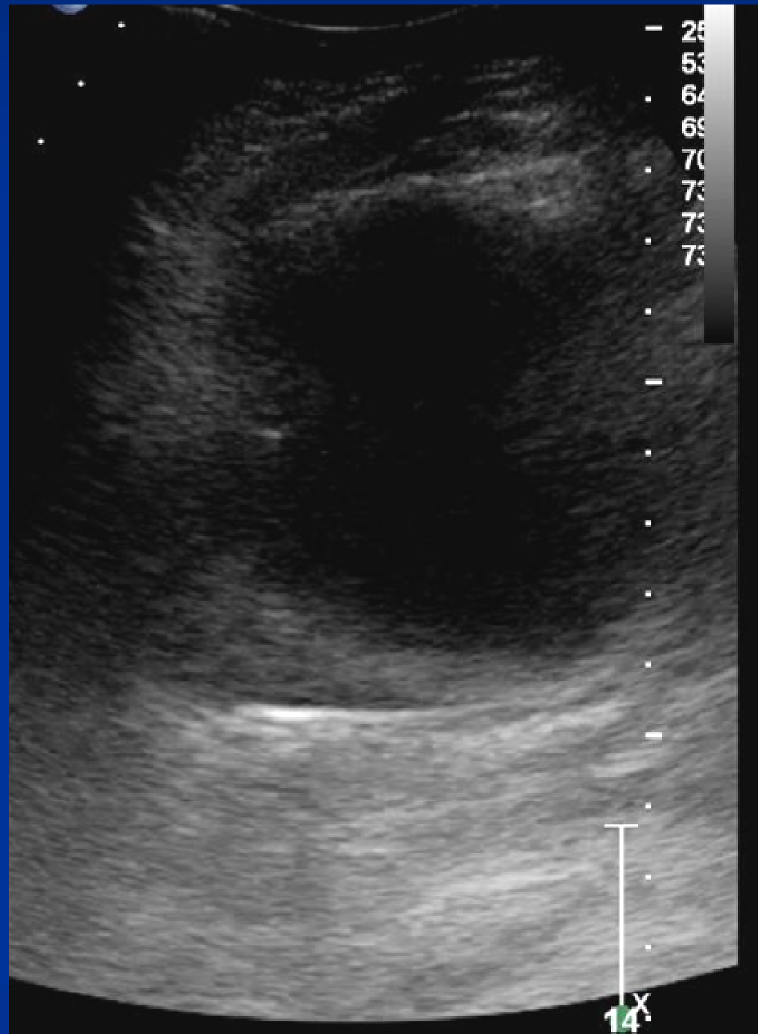
- Microbubbles stabilized by phospholipids
- It contains Sulfur-hexafluorid (SF_6) – inert gas, excreted trough lungs respiration

- Increase in signal intensity for 3-8 min.

Liver

B-mode

- When you could say definite diagnosis:
  - Typical liver cyst
  - Calcification



- All other focal hepatic lesions are characterized not only by differences in echogenicity, but also due to different vascularization bearings and due to changes in perfusion kinetics.

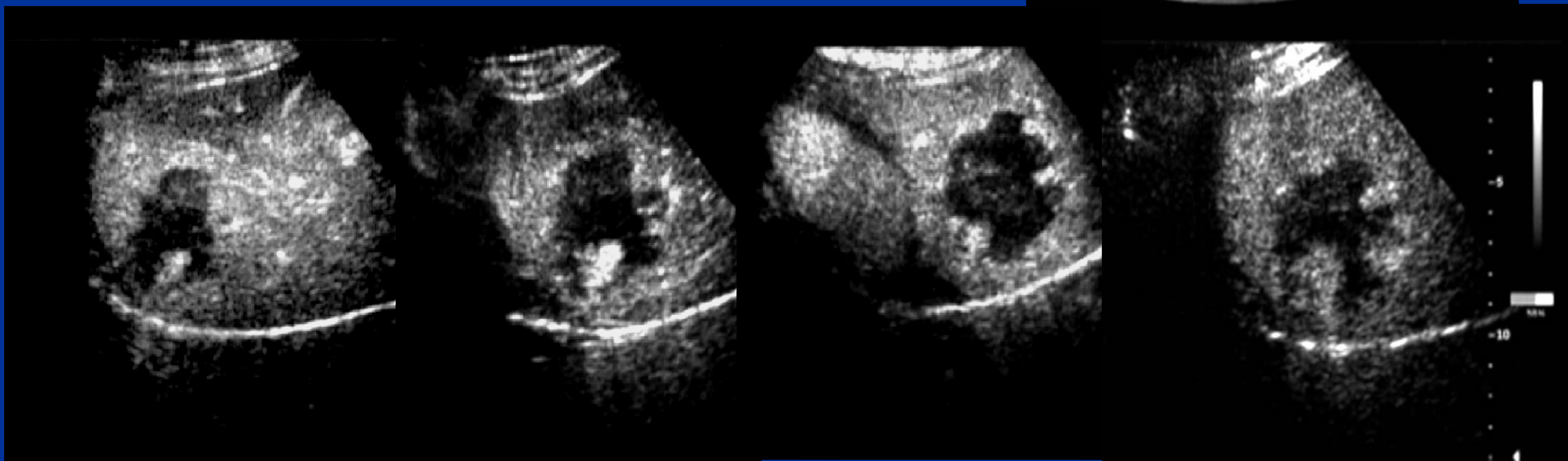
- Due to the dual blood supply of the liver by portal vein and hepatic artery, we do not judge only according to whether they are hypo- or hypervascular but also saturation depends on the perfusion stage and thus on the histological structure

Dose

- Normal liver
  - 1,5ml i.v. bolus + FR
- Cirrhotic liver, fat patient, deep lesion
  - 2,0 ml i.v. bolus + FR

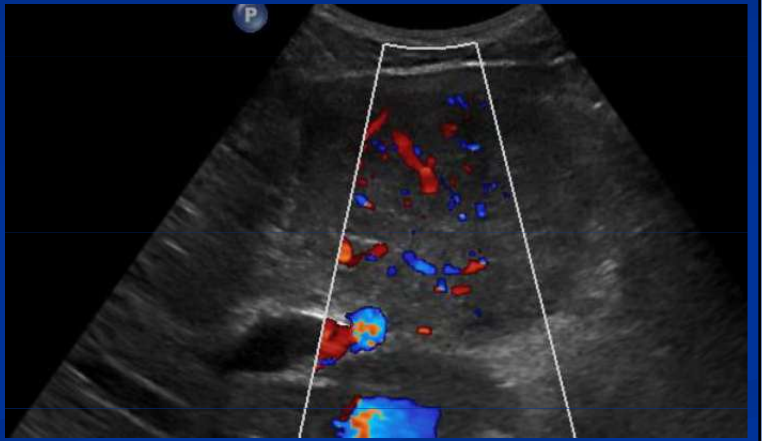
Hemangioma

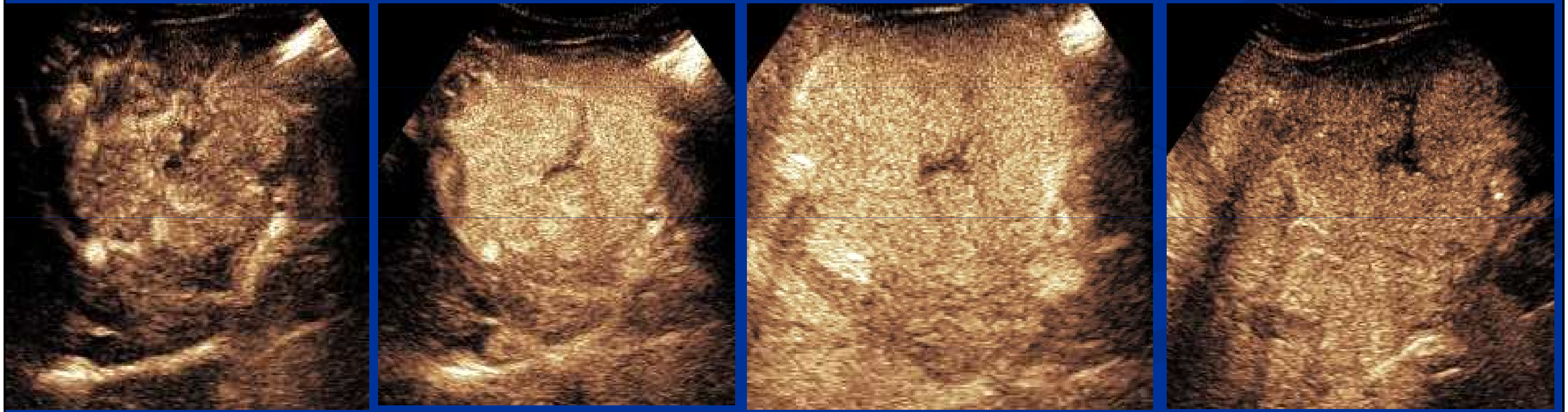
- the most common benign liver tumor
- often an incidental finding
- usually stable, but can vary in time
- can also grow rapidly



Focal nodular hyperplasia

- Second the most common benign liver tumor
- contains hepatocytes, elements of bile ducts, Kupffer cells, fibrous stroma and often "central scar"(50%)
- typically random finding in women





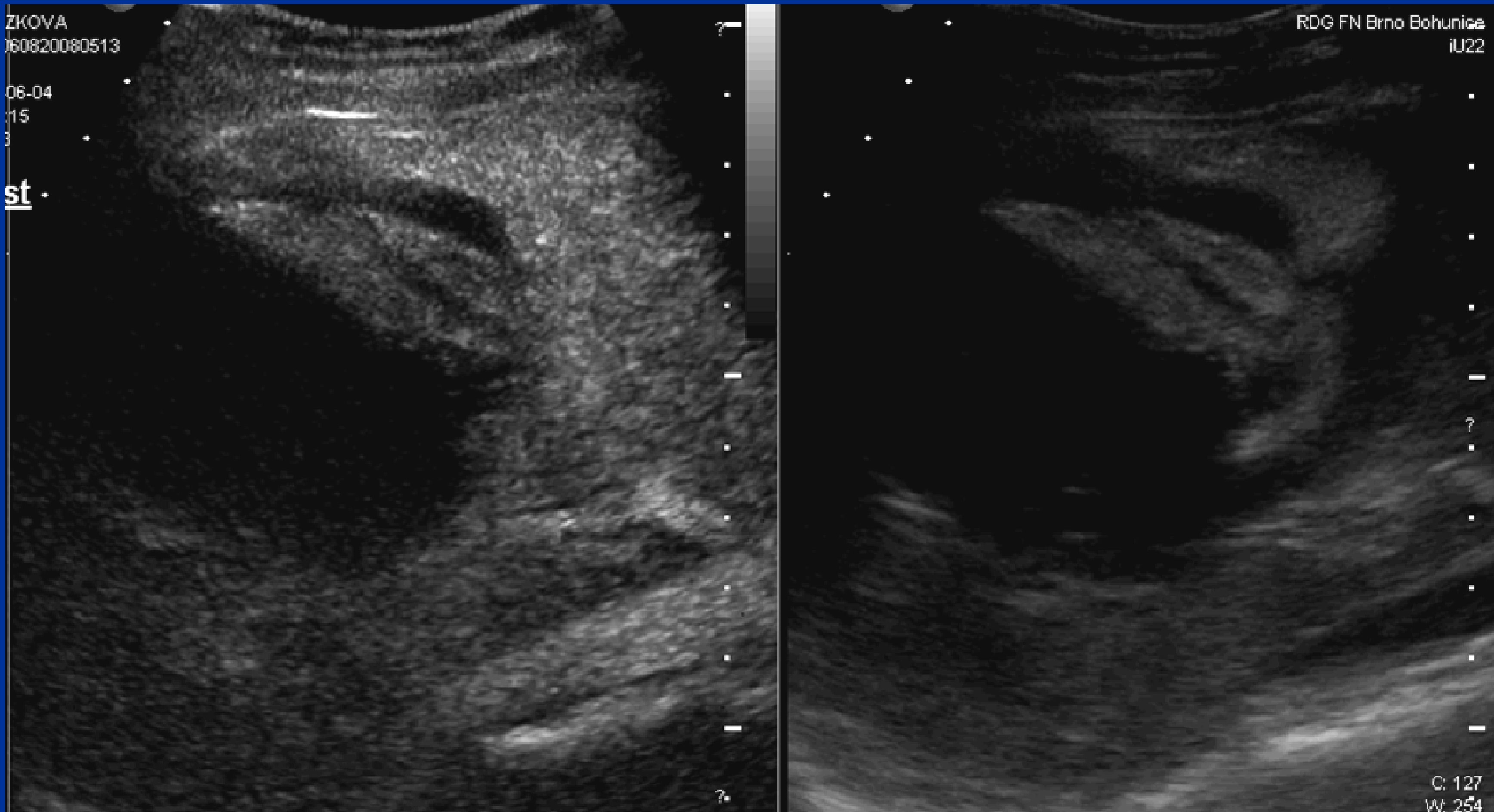
Hepatocellular adenoma

- relatively rare benign tumor is potentially malignant
- Associated with oral contraceptives, 90% young women .
- Frequent cause of pain because of it contains necrosis and hemorrhage
- primarily arise from hepatocytes may contain fat, often contain intracellular glycogen, they tend to have a thin pseudocapsule, lack architectonics, there is a relatively small amount of bile ducts and often degenerative necrosis

HA

inhomogeneity (hyperechoic districts of acute hemorrhage, hypo- to unechogenic in older bleeding)

homogeneous saturation in the arterial phase, zero saturation in portovenose phase poorly distinguishable - coincides with the parenchyma in late (sinusoidal) phase pericapsular vessels.

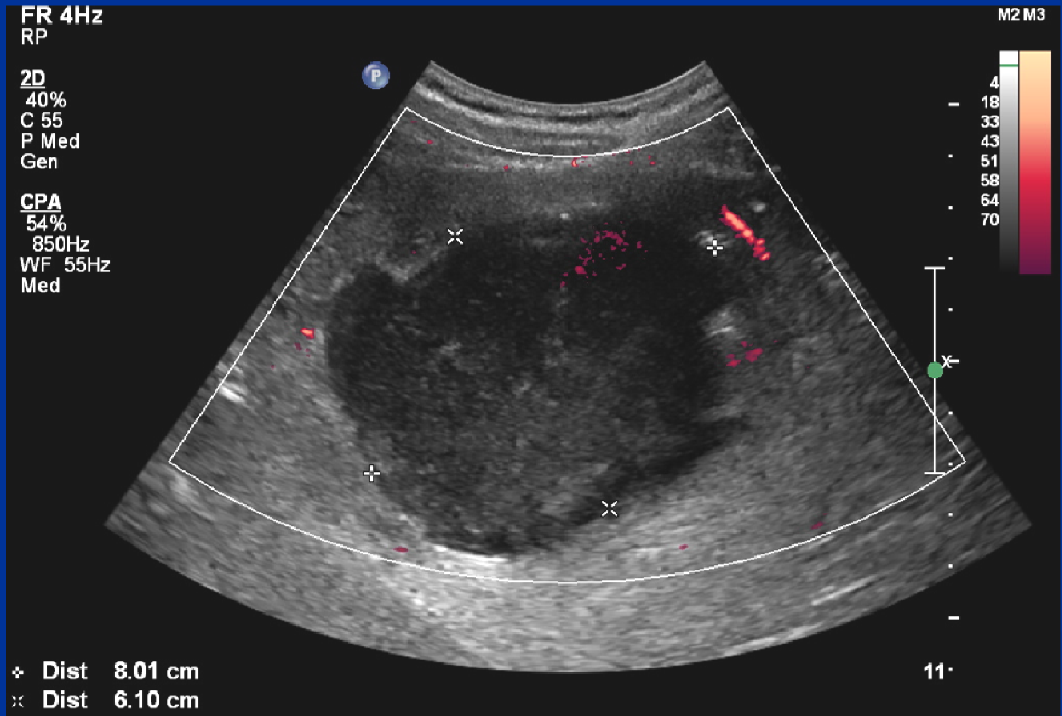


Liver absces

Symptoms are often non-specific

Findings on nativ US is sometimes nonspecific and difficult to distinguish from tumor necrosis

Content of the gas is a specific finding, but is present less than 20% of cases

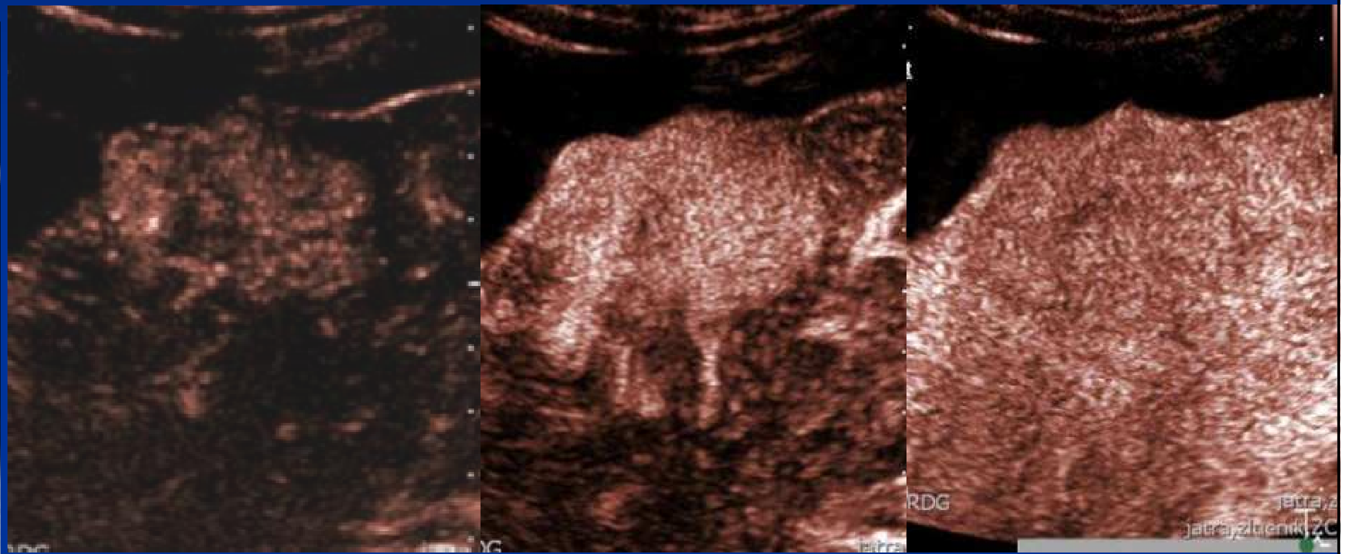


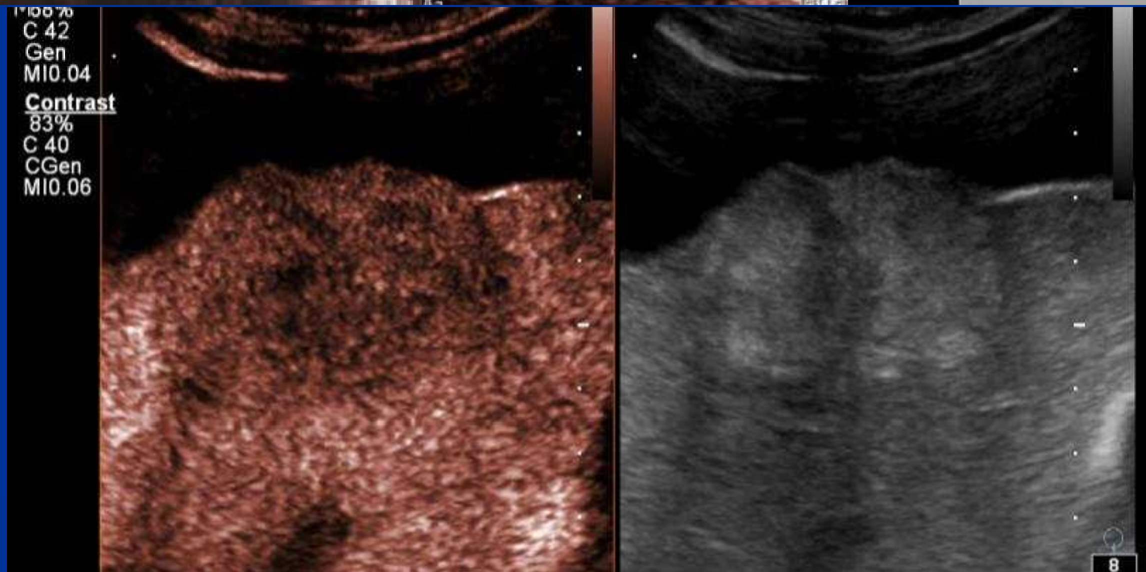
Hepatocelullar carcinoma

- The most common primary malignant liver tumors
- associated with cirrhosis, chronic active hepatitis, hemochromatosis
- larger HCC usually hypervascular

HCC

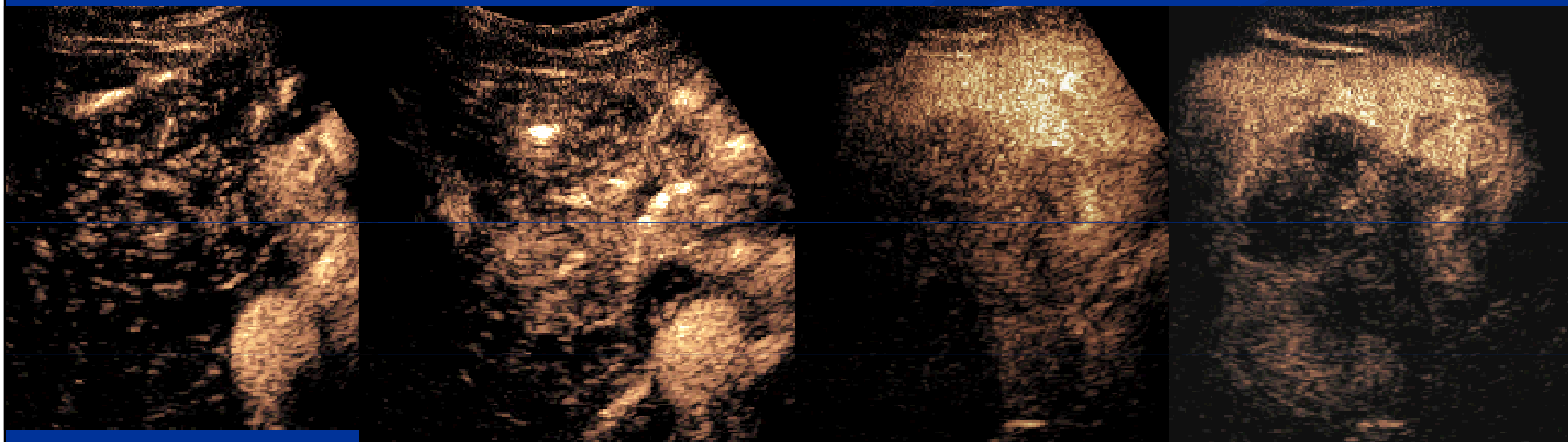
Intensive saturation with a rapid increase (time to peak) in the arterial phase, a relatively rapid wash-out in portal phase





Cholangiocarcinoma

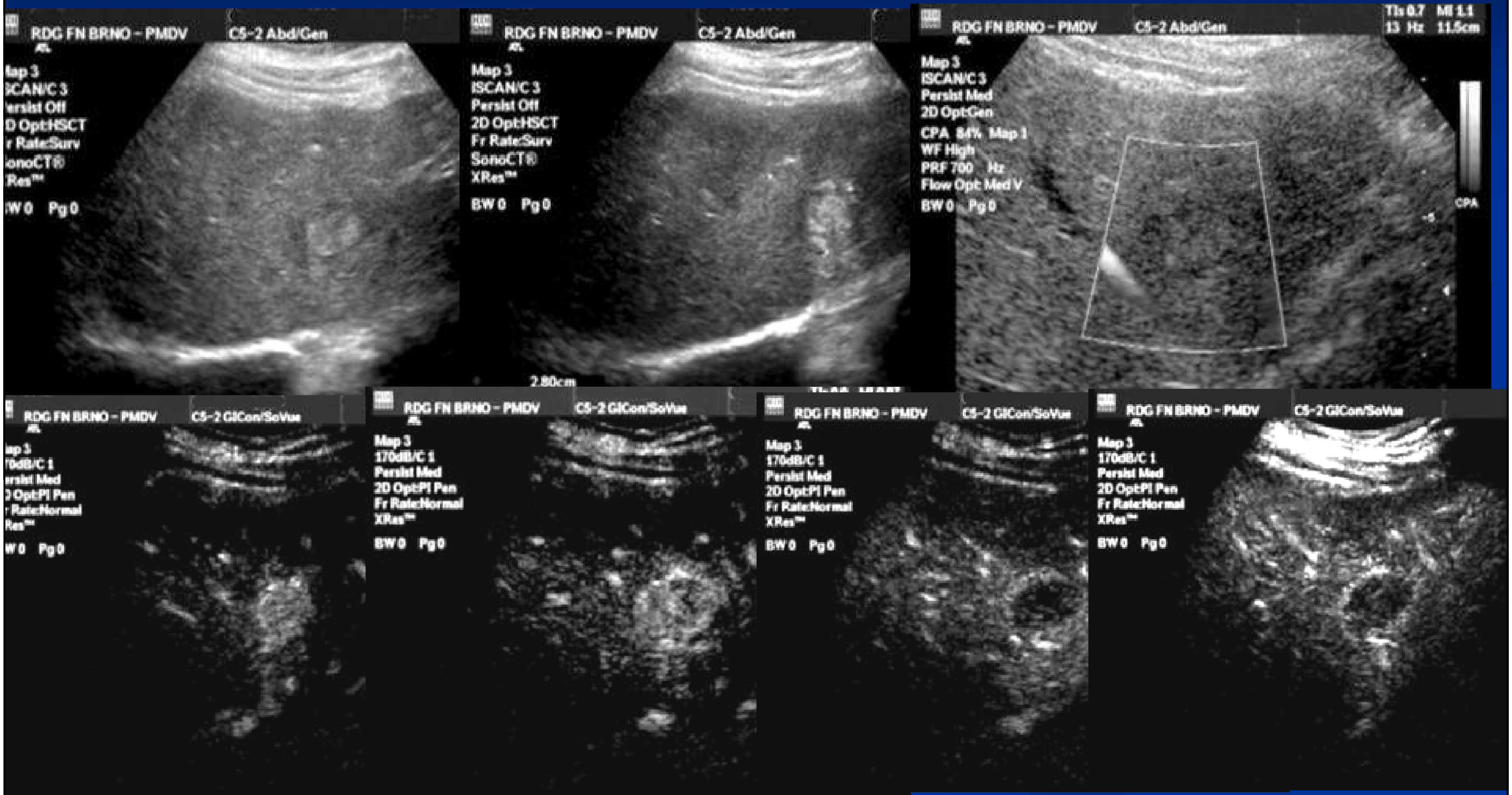
- HCC less frequent and in older patients
- hypovascular tumor



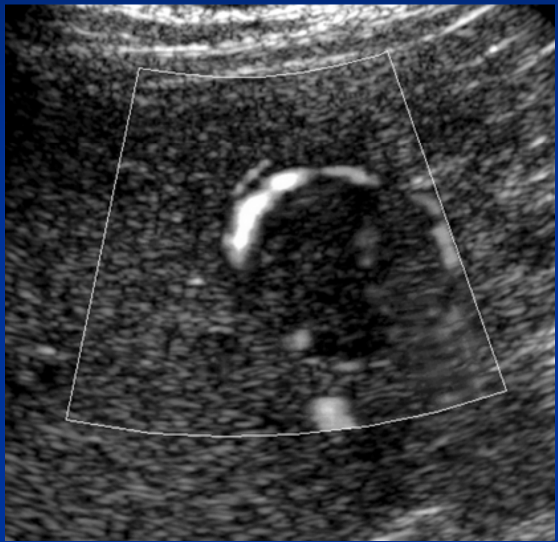
Metastasis

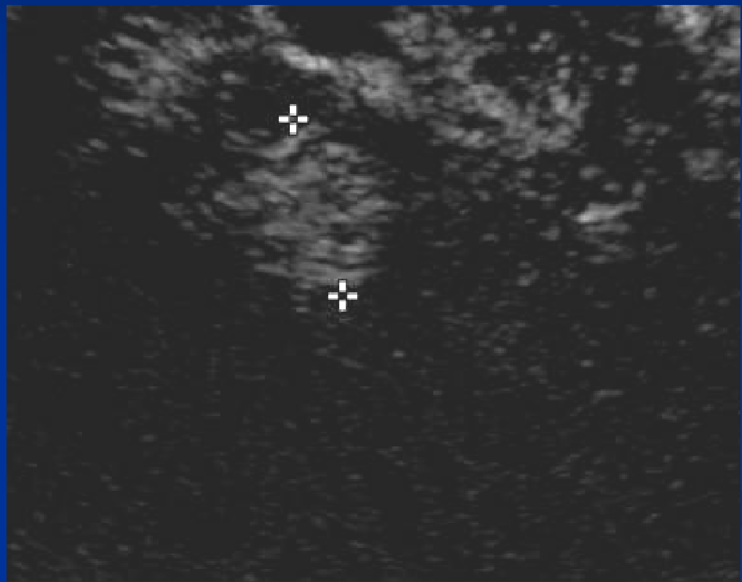
- the liver is the most common site of distant metastasis
- They have great variability, may be cystic, solid, mixed, hypervascular or hypovaskular

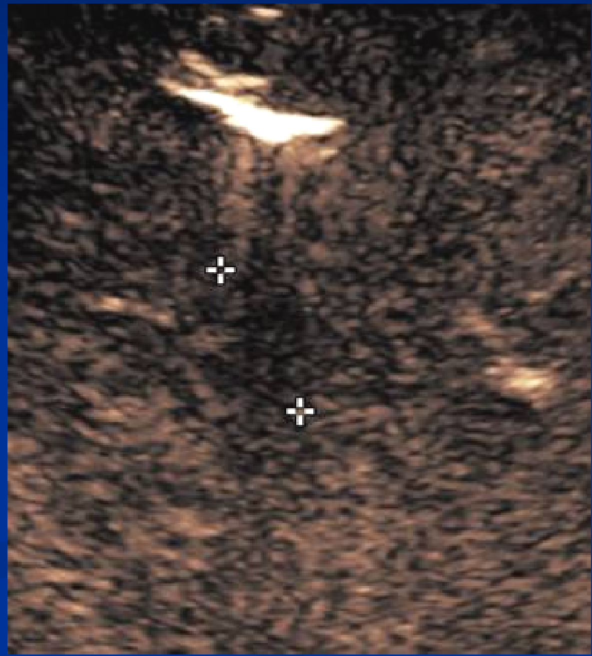
Colrectal carcionma metastasis



Hypervascular metastasis (karcinoid)





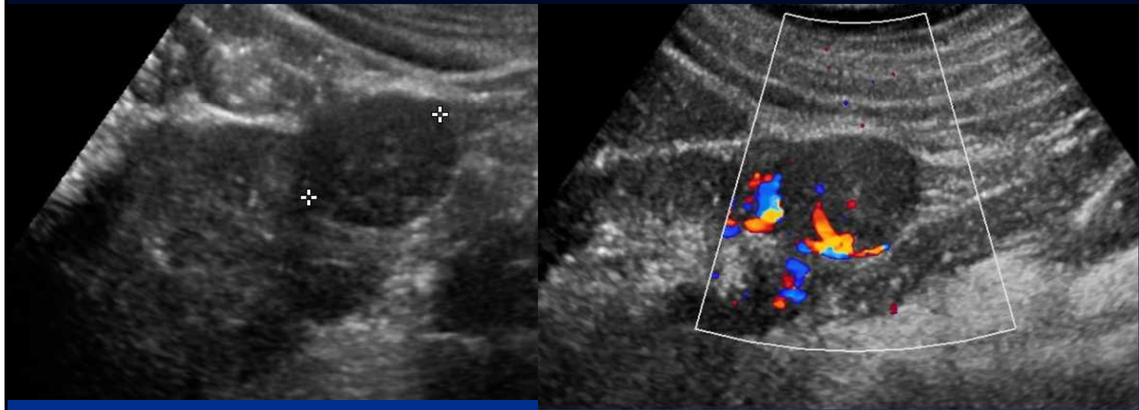


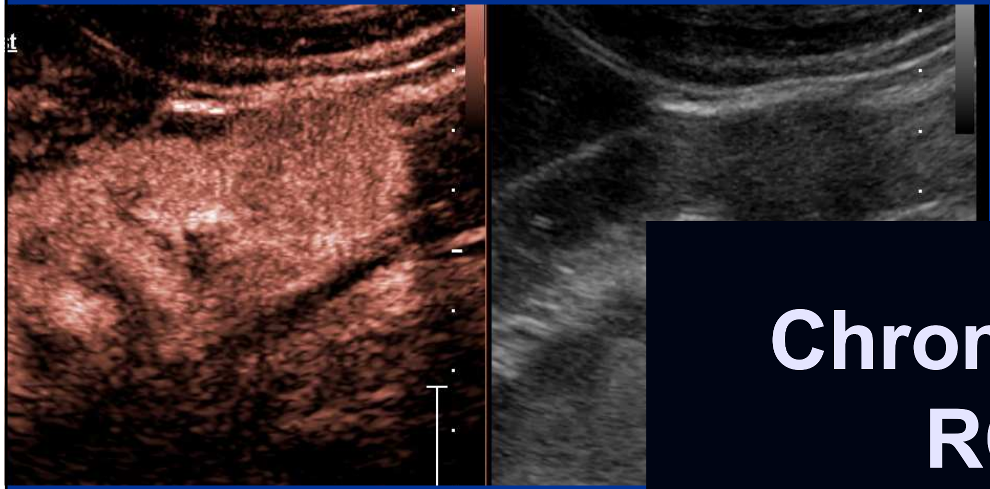
Kidneys

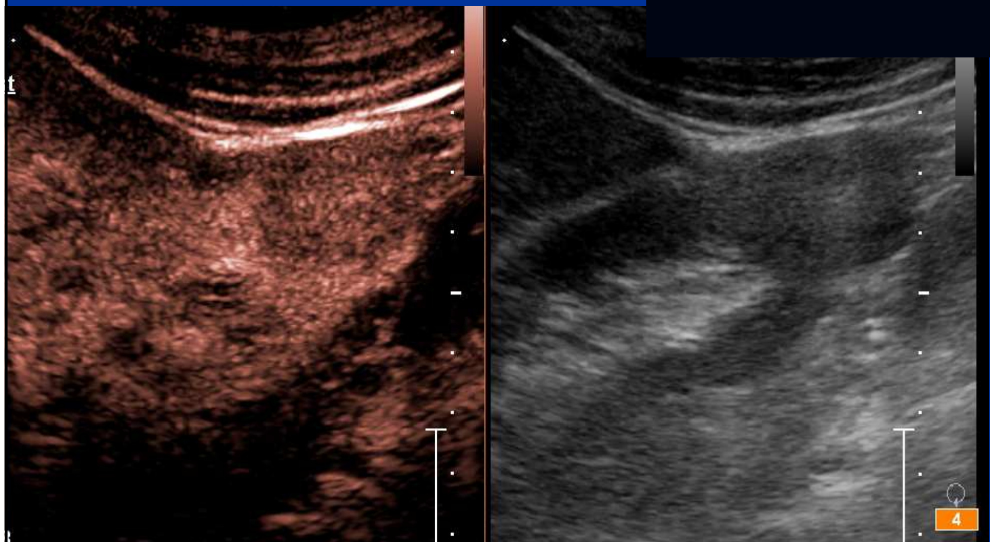
When we use it

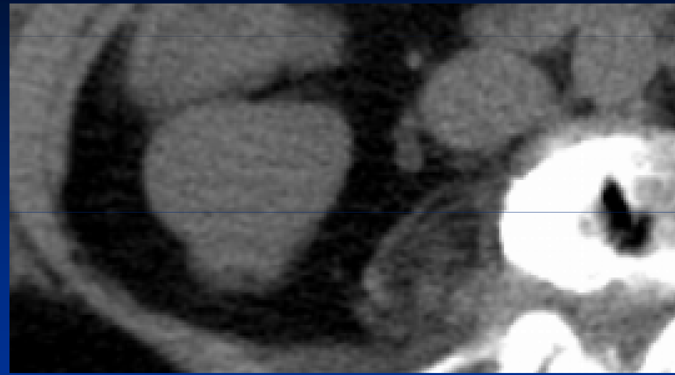
- We can differentiate solid lessions from cystic
- Gradeing of cystic lessions - Bosniak classification

Case 1



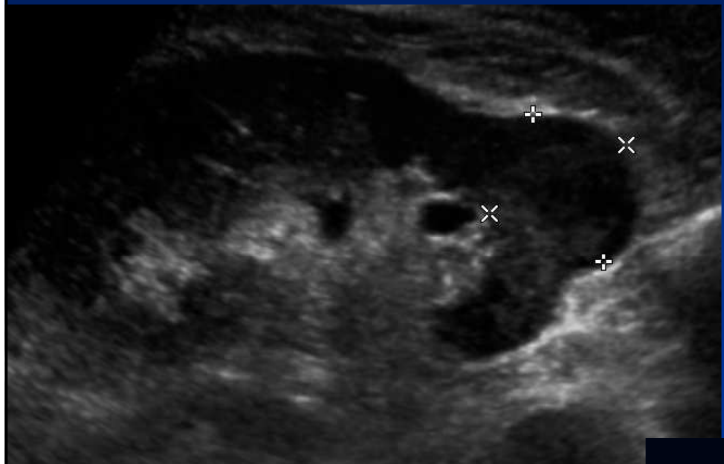


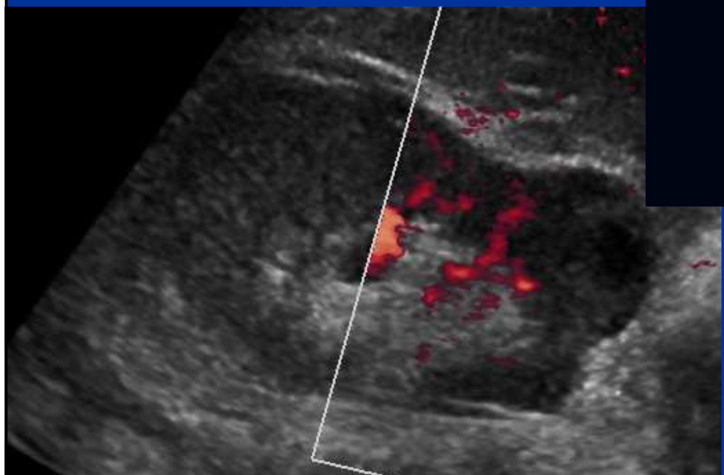




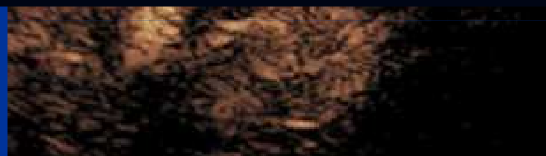
Chromofobe RCC

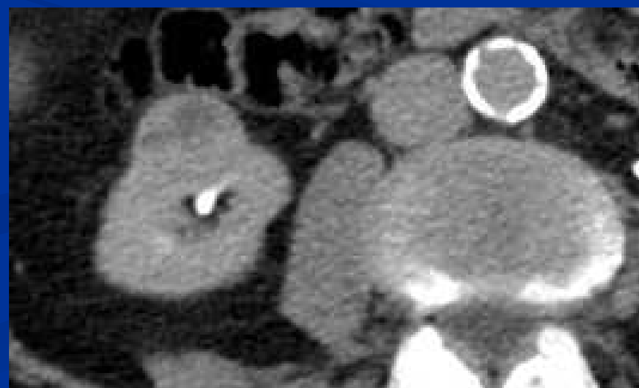
Case 2



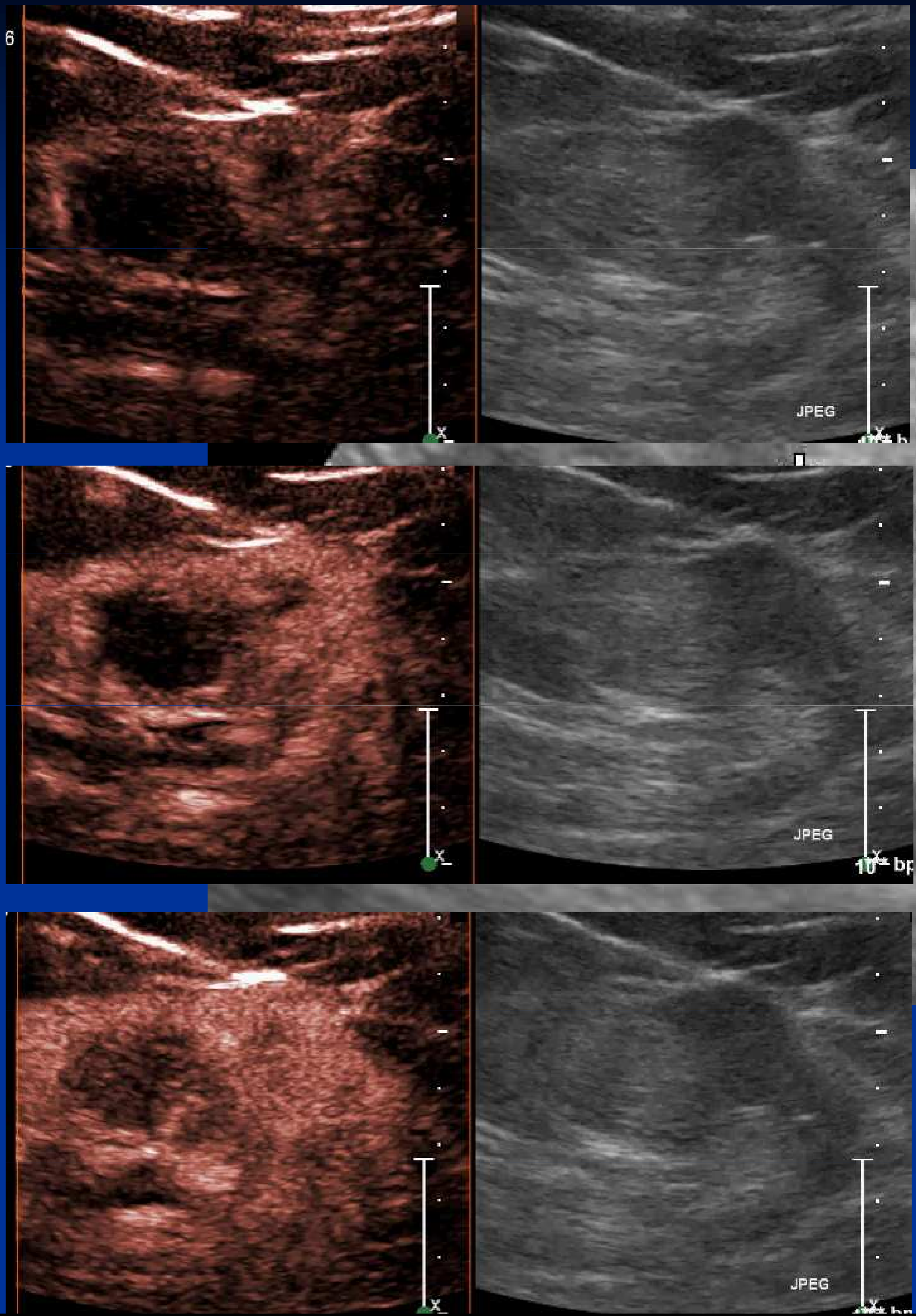


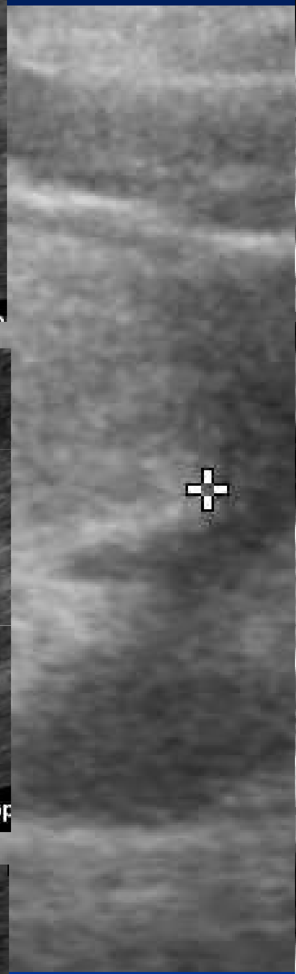
Onkocytoma

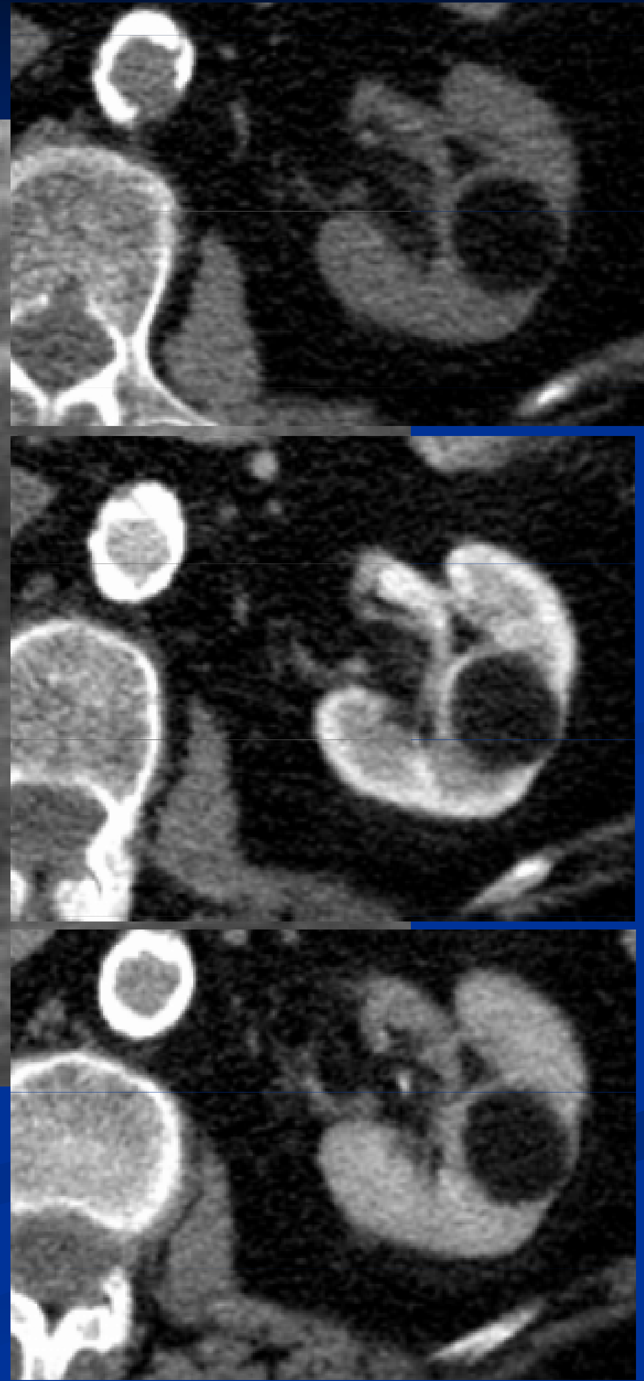




Case 3



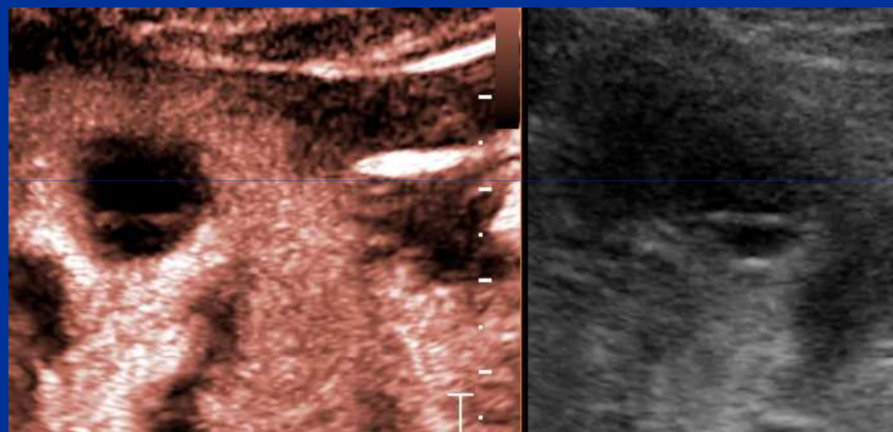




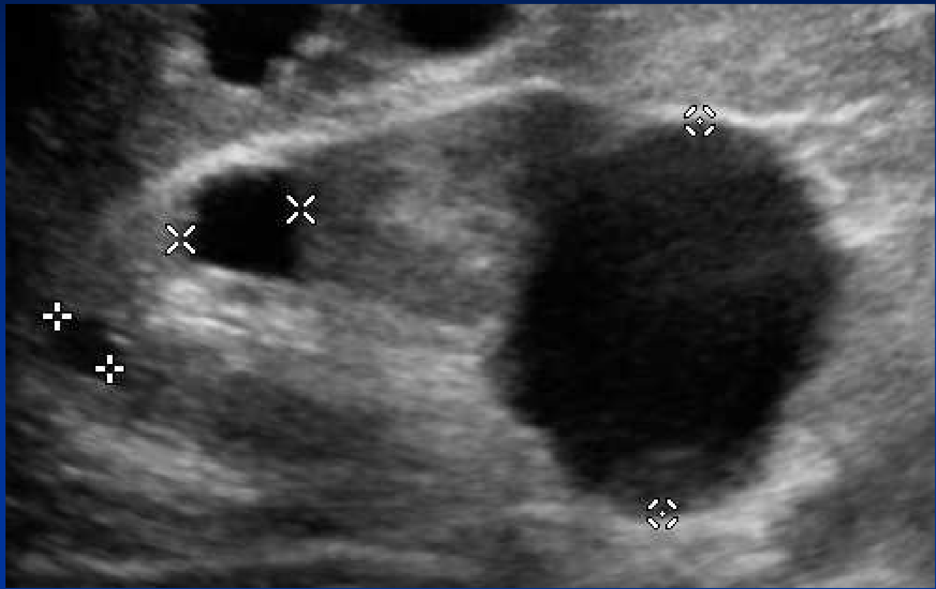
kidney cysts

- Standard: CT – Bosniak classification

I, II - benigne
IIF - probably benigne, track
III - 50% maligne
IV - almost 100% maligne

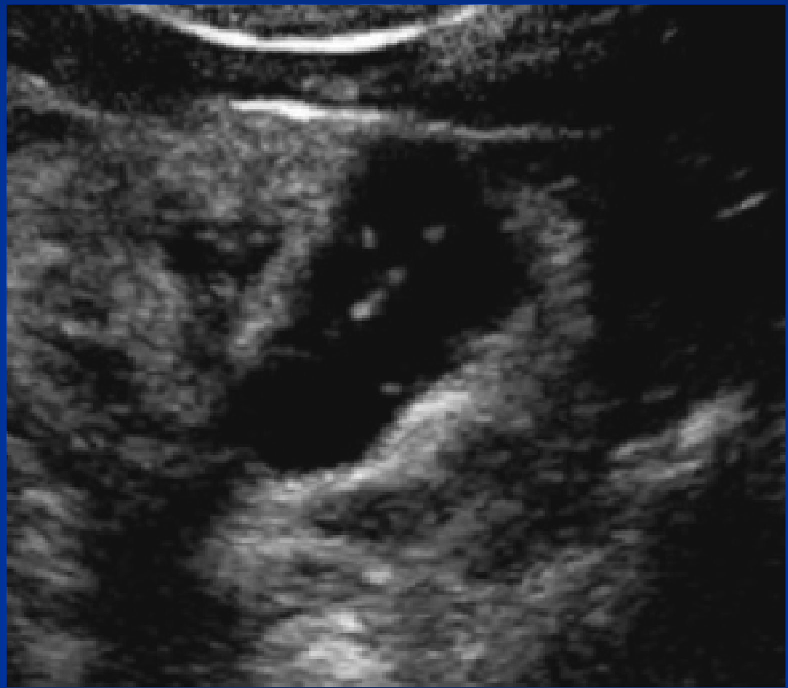
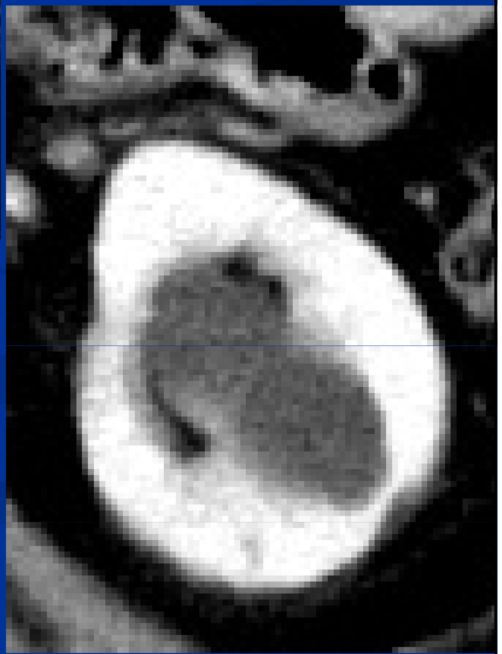


Bosniak I



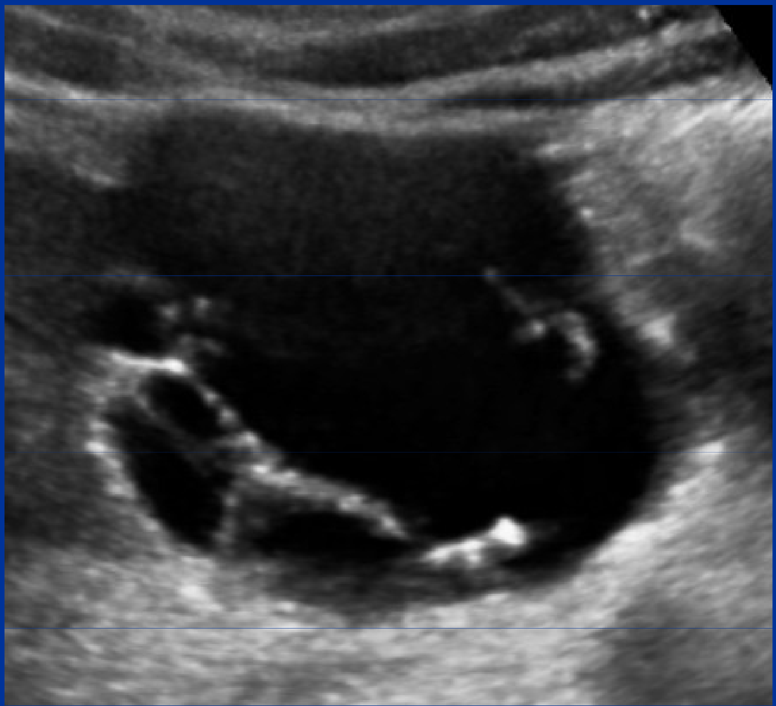
Bosniak II

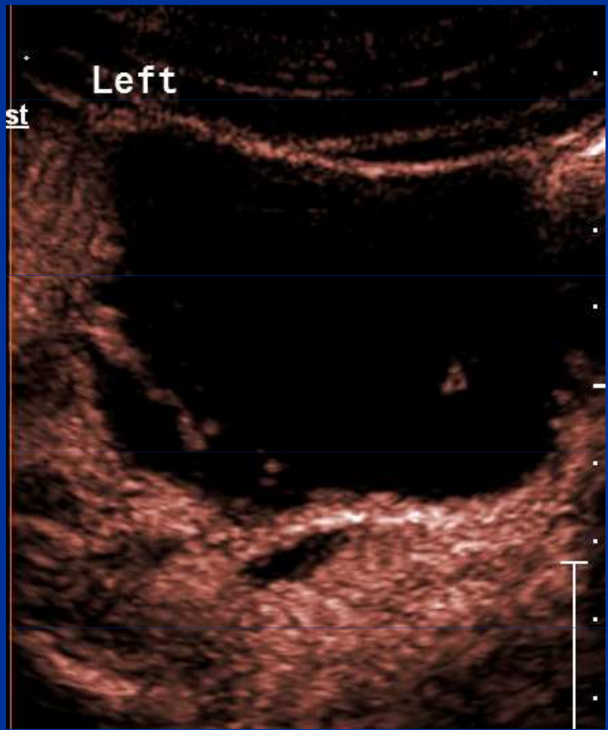
- thin septs, sometimes you can watch the gentle enhancement of septs

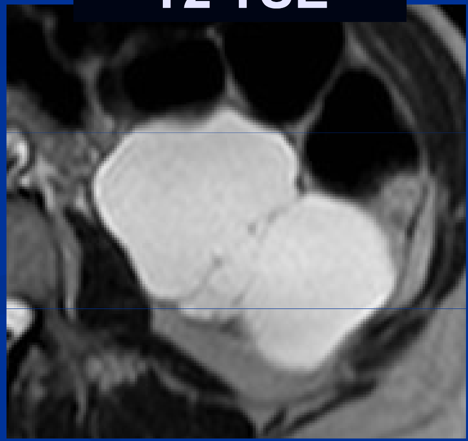
Bosniak IIF

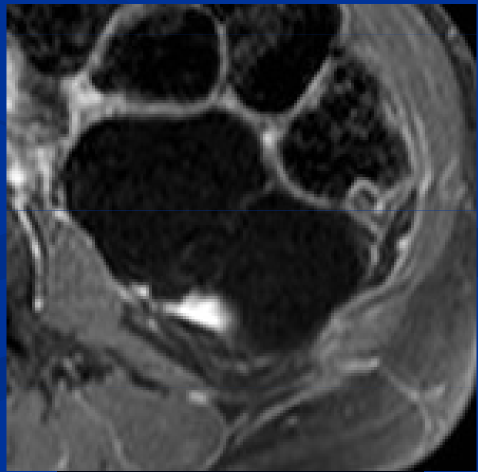
- More septs, and theyr enhancement
- wall thickening without enhancement





T2 TSE

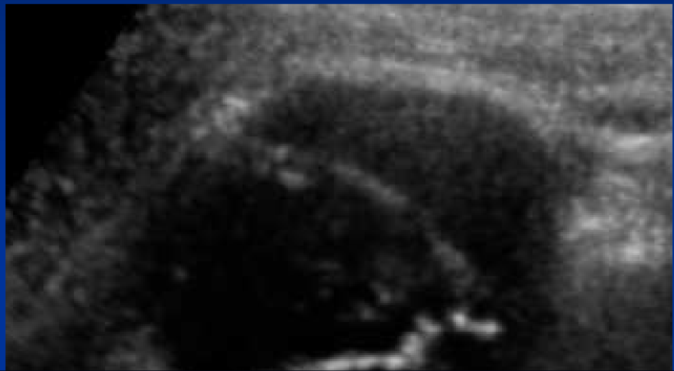




T1 k.l.

Bosniak III

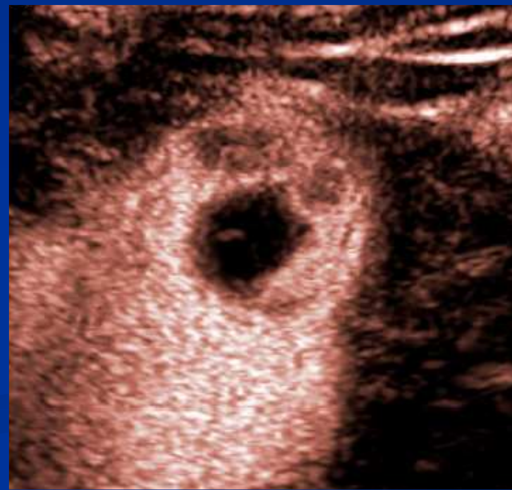
- thickened wall, or septum, with enhancementh



Multilocular cystic nefroma

Bosniak IV

- Solid soft tissue nodul with enhancement



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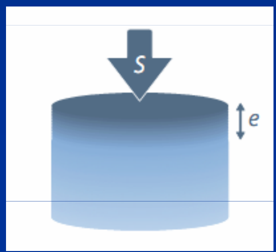
Elastografie

Radiologická klinika FN Brno a LF MU

Basis principles of elastography

- It uses ultrasound to determine the difference in rigidity (elasticity) of the tissues
- Tissue stiffness is generally expressed by Young's modul (unit - Pa))



$$E = \frac{S}{e}$$

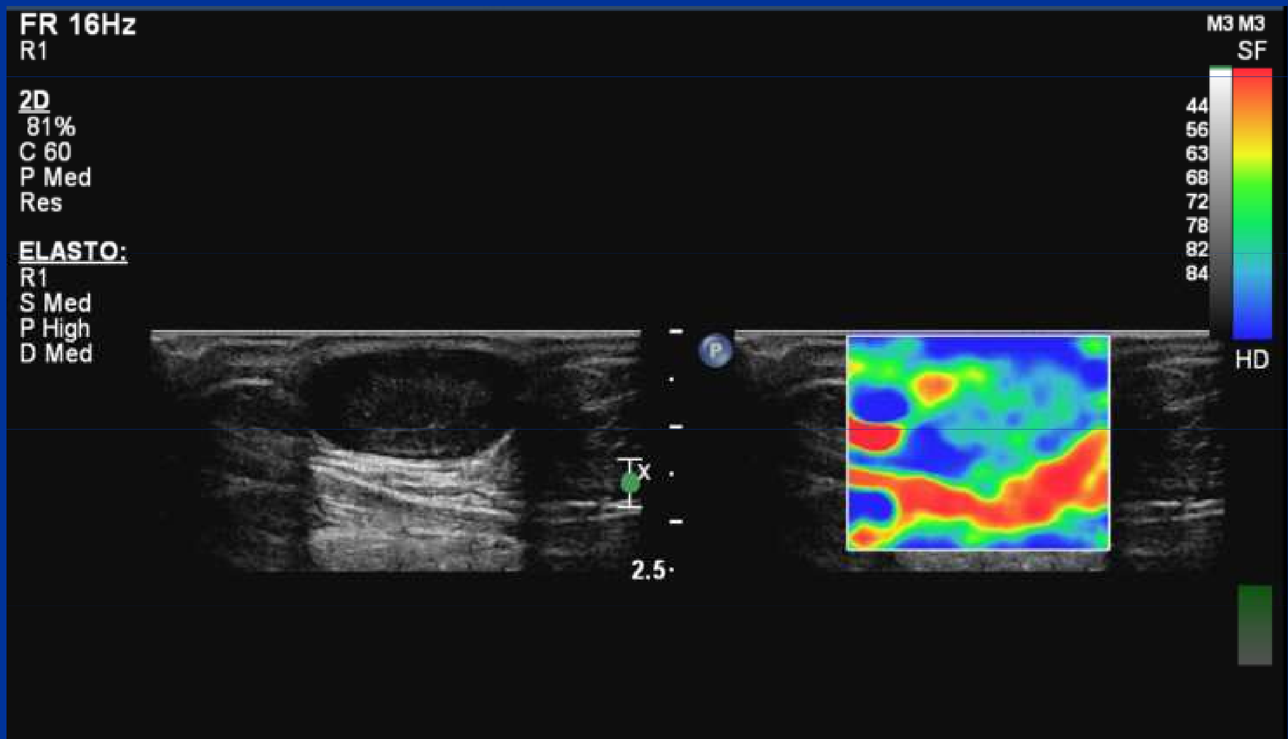
the ratio between the applied pressure (S) and the induced strain (e)

  - More stiffness = higher Young model

Type of soft tissue		Young's Modulus (E in kPa)	Density (kg/m³)
Breast	Normal fat	18-24	1000 +/- 8% ~water
	Normal glandular	28-66	
	Fibrous tissue	96-244	
	Carcinoma	22-560	
Prostate	Normal anterior	55-63	
	Normal posterior	62-71	
	BPH	36-41	
	Carcinoma	96-241	
Liver	Normal	0.4-6	
	Cirrhosis	15-100	

Strain elastography

- This method use compression of tissue by own patients movement (breathing, moving of the heart and blood vessels)
- In this method we can only make color maps, but not mesure values of preasure



Shear wave elastography

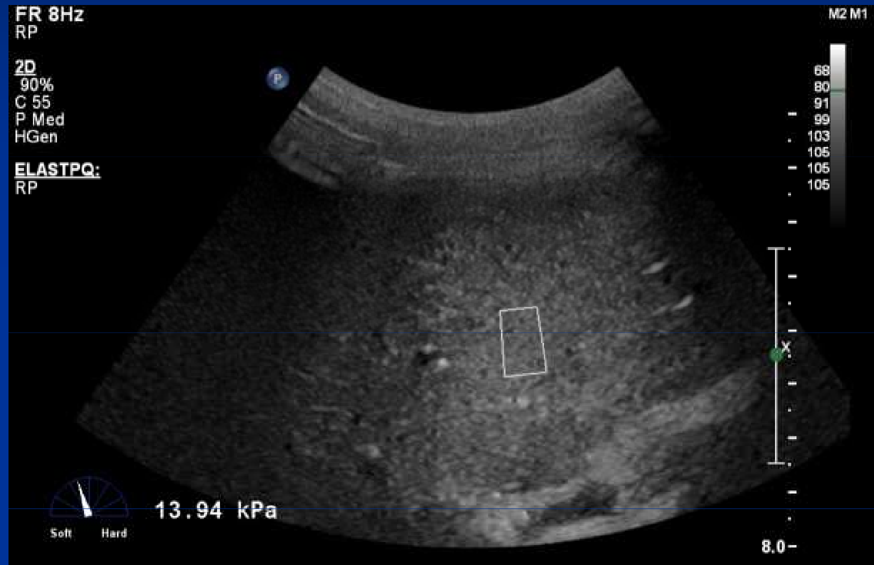
- With appropriate ultrasound waves, we can generate both longitudinal and transverse waves (shear waves)
- transverse waves (shear waves) formed as a response of elastic tissue resistance to vibrations with low frequency
- source of vibration are pulses of acoustic pressure generated by focused ultrasound
- And we can measure it

$$E = 3\rho c^2$$

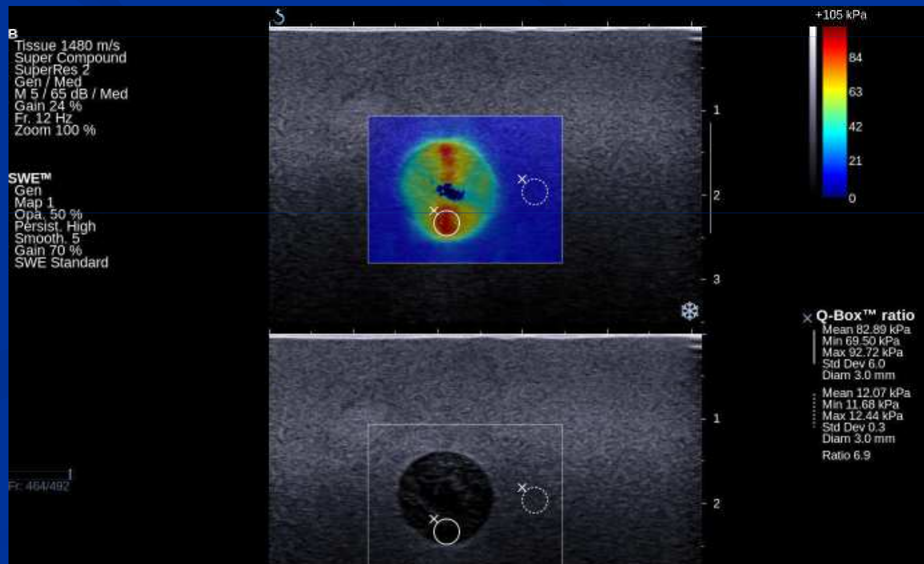
E ... elasticity [Pa]
ρ ... Density of environment [$kg.m^{-3}$]
c ... velocity of propagation [$m.s^{-1}$]

Shear wave elastografie

- One point – static(number)



- Dynamic – on line colour map



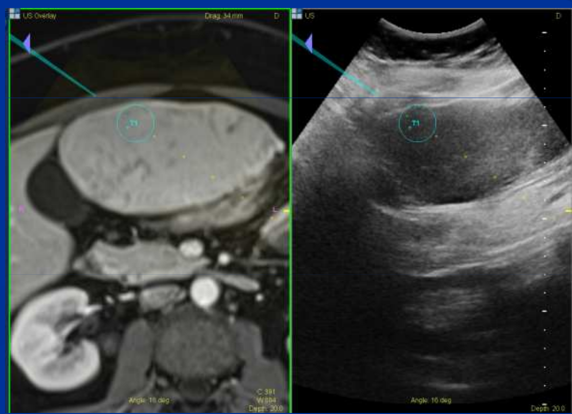
Where we can use it

- Lover
  - Grade of fibrosis
- Spleen
  - Portal hypertensis
- Thyroid gland
- Brest lessions

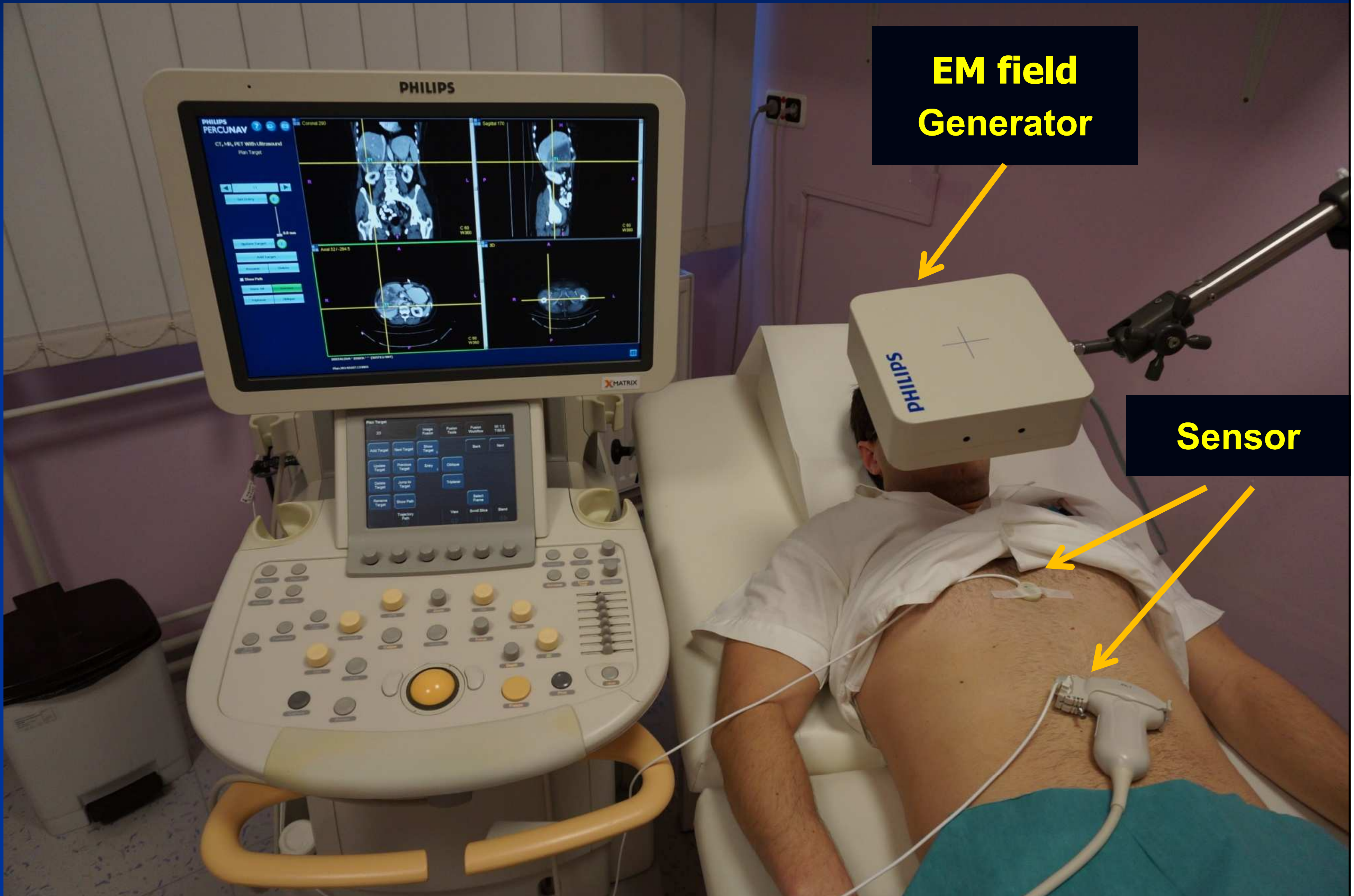
Navigation systems

System functions

- real-time fusion of US/CEUS with (CT, MR, PET/CT)
- Navigated intervencion with special needles
  - Biopsi
  - Ablacion



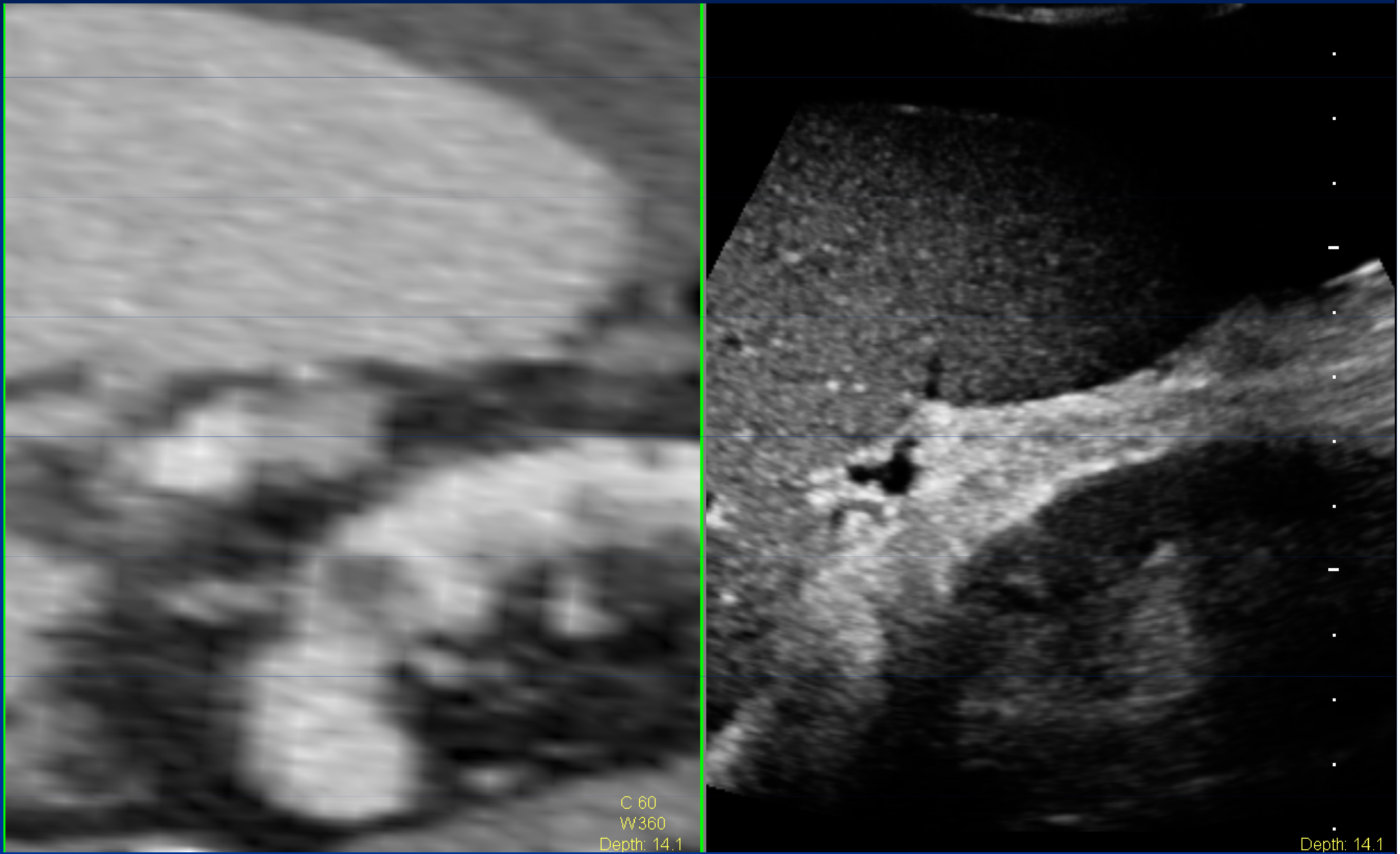
Machine



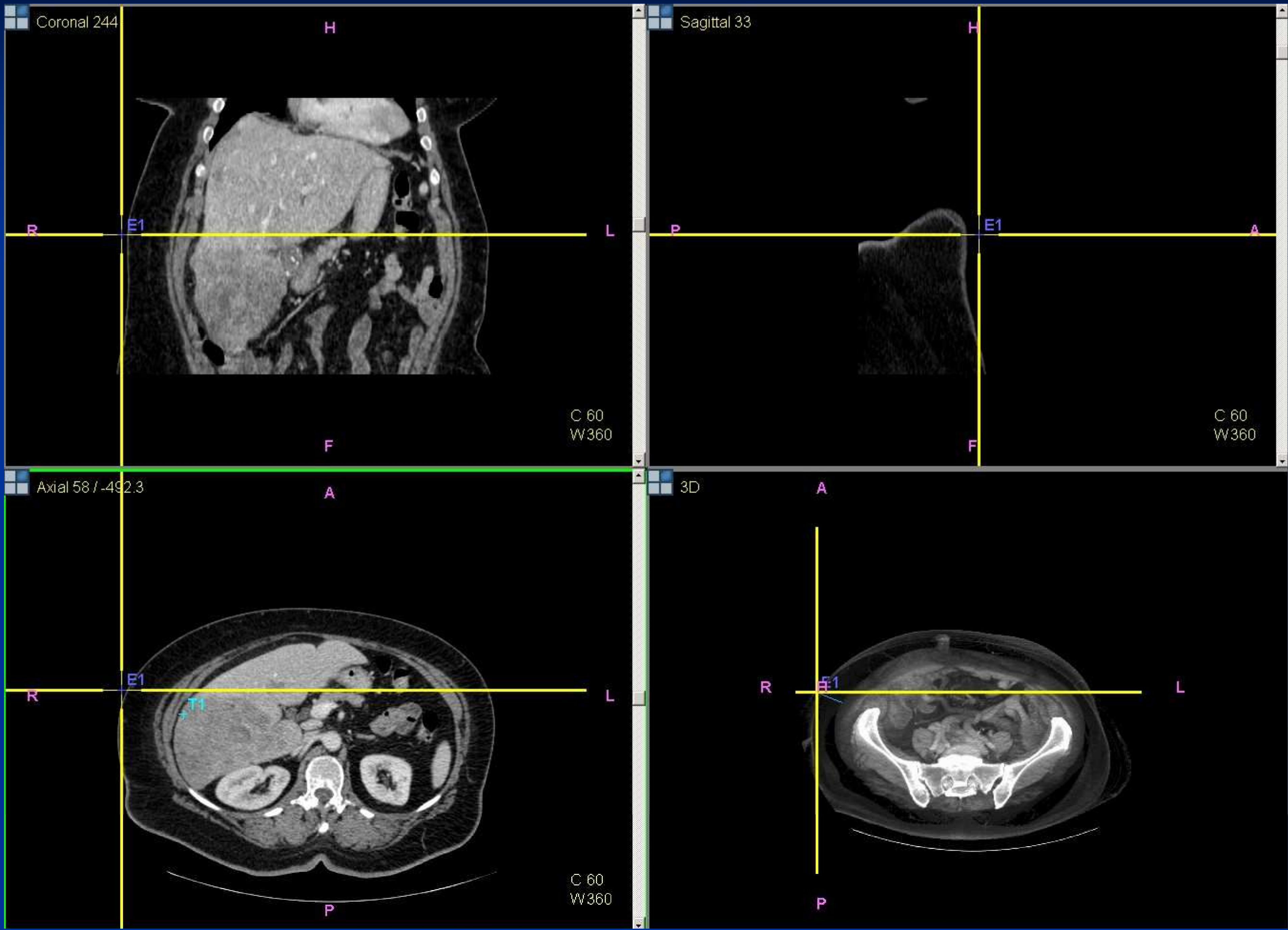
Fusion CT +UZ

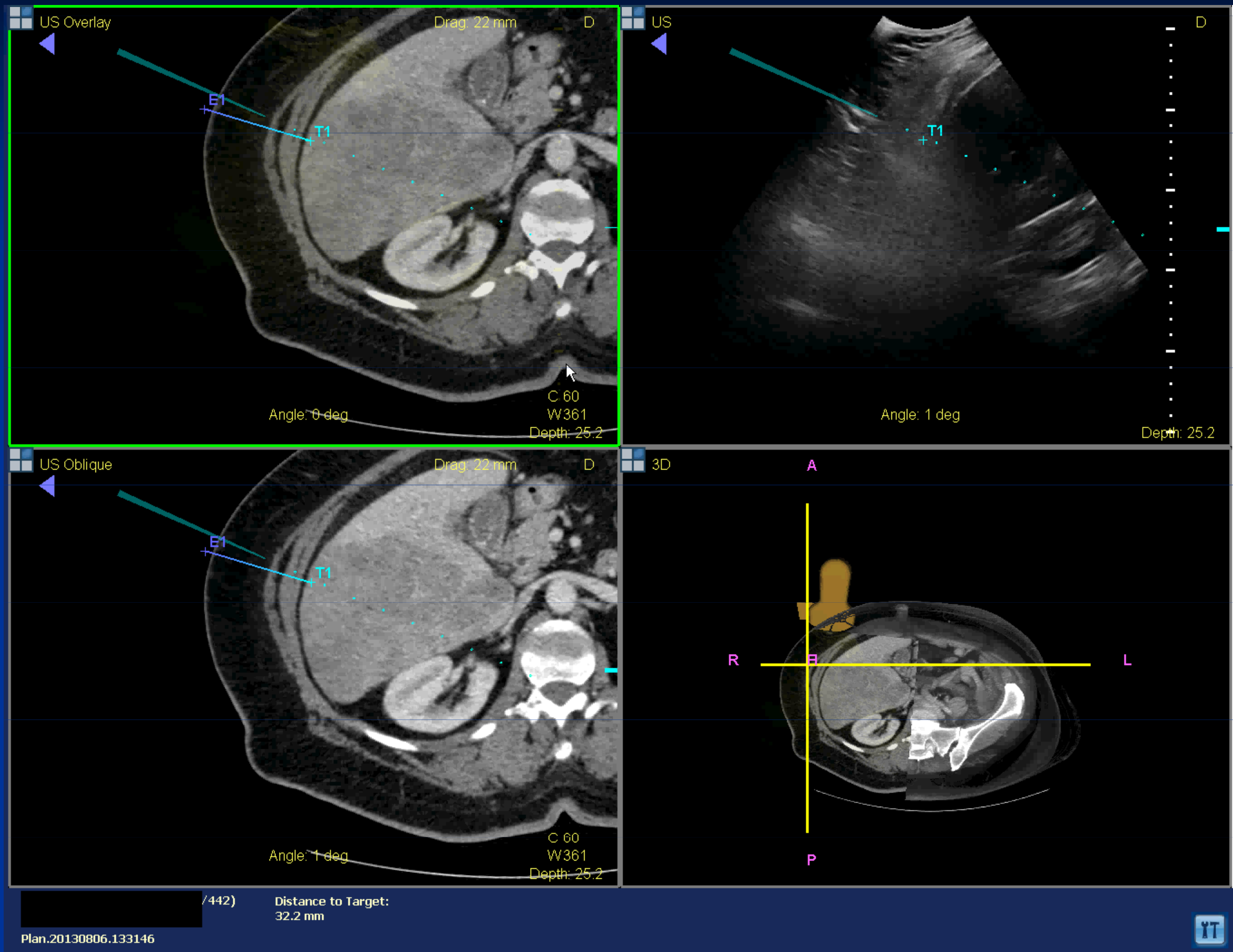
PHILIPS
PERCUNAV
CT, MR, PET With Ultrasound
Live
Freeze
Probe Not Selected
DRF
C5-1
Offset: 0.0 mm Roll: 0.0 deg
Layout
Target
Add
Delete
Rename
Show Current
Blend:
Gate
Flip
Beep
2013-10-15
08:09:16
Contrast Timer
US Overlay
Drag: 584 mm
D
C 40
W400
Depth: 14.1
US
D
Depth: 14.1
Anonymized: Press Name ID key to redisplay.
Distance to Target:
N/A
Plan.20131015.075451

Use of fusion



Fusion + navigation - planning




US Overlay
Drag: 22 mm
D
E1
T1
Angle: 0 deg
C 60
W361
Depth: 25.2
US
D
T1
Angle: 1 deg
Depth: 25.2
US Oblique
Drag: 22 mm
D
E1
T1
Angle: 1 deg
C 60
W361
Depth: 25.2
3D
A
R
L
P
[redacted] /442)
Distance to Target:
32.2 mm
Plan.20130806.133146

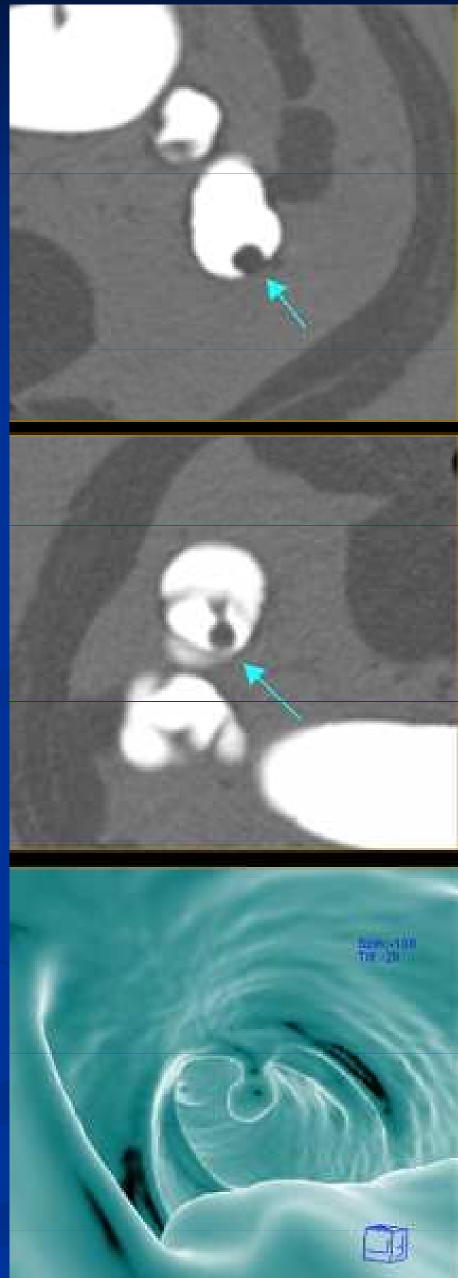
Computed tomography

1) VIRTUAL COLONOSCOPY

2) Spectral CT

VIRTUAL COLONOSCOPY
Indication

- Examinatio is intended to detect polyps and carcinomas, in case that the optical colonoscopy is:
- incomplete (anatomy, spasm, stenosis, adhesion ..)
- intolerance or rejection by the patient
- contraindicated
- unclear findings at OC
  increased risk of complications during OC (anticoagulation, age ...)



It is not yet approved for colorectal cancer screening

Reliable detection in larger polyps (above 5 mm) and cancers

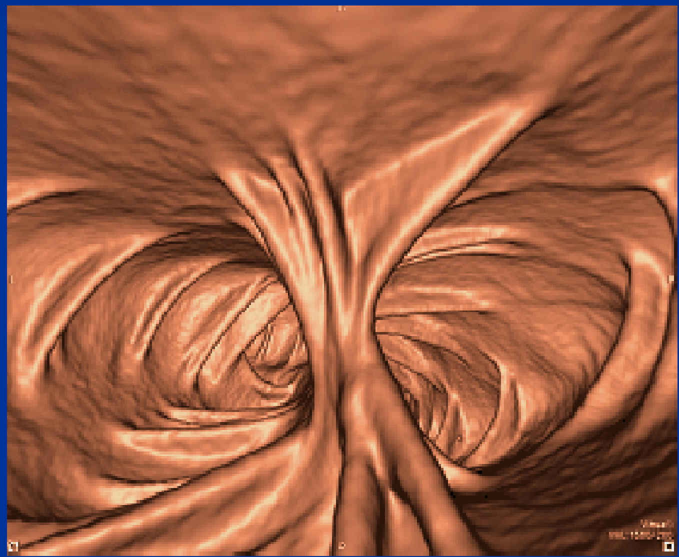
Advantages VIRTUAL COLONOSCOPY

Low-dose technic (about 7-8 mSv)

Nonivasive, no pain

You can avaluate wall and surroundings of bowl, and i native picture whole abdomen.

You see behind stenosis



Disadvantages – les accurate

No interventions

Arteficial findings(faeces, resiodual intraluminal material)

Examination

Preparation for examination is same as on normal colonoscopy

+

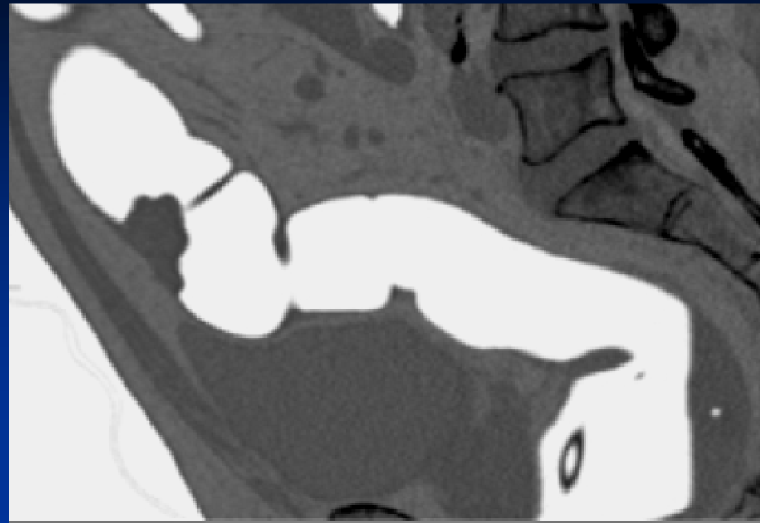
Night before posive contrast peroral for faecaes marking

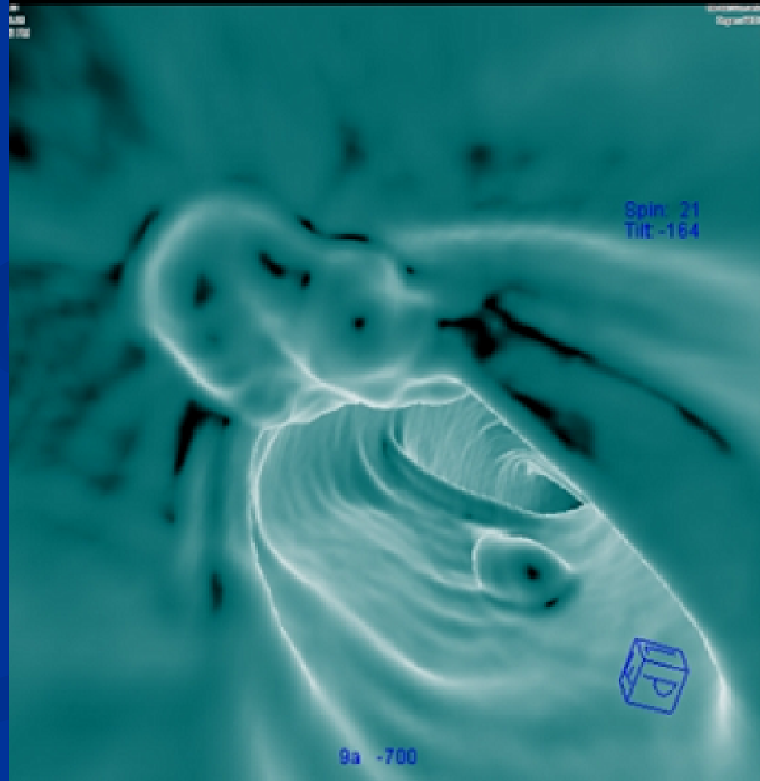
+ closely before examination:

Hypotony– 1ml Buscopan i.v.

Insuflation of CO2 on preasure between 6-25mmHg..

Than CT examination two positions: on the abdomen and back



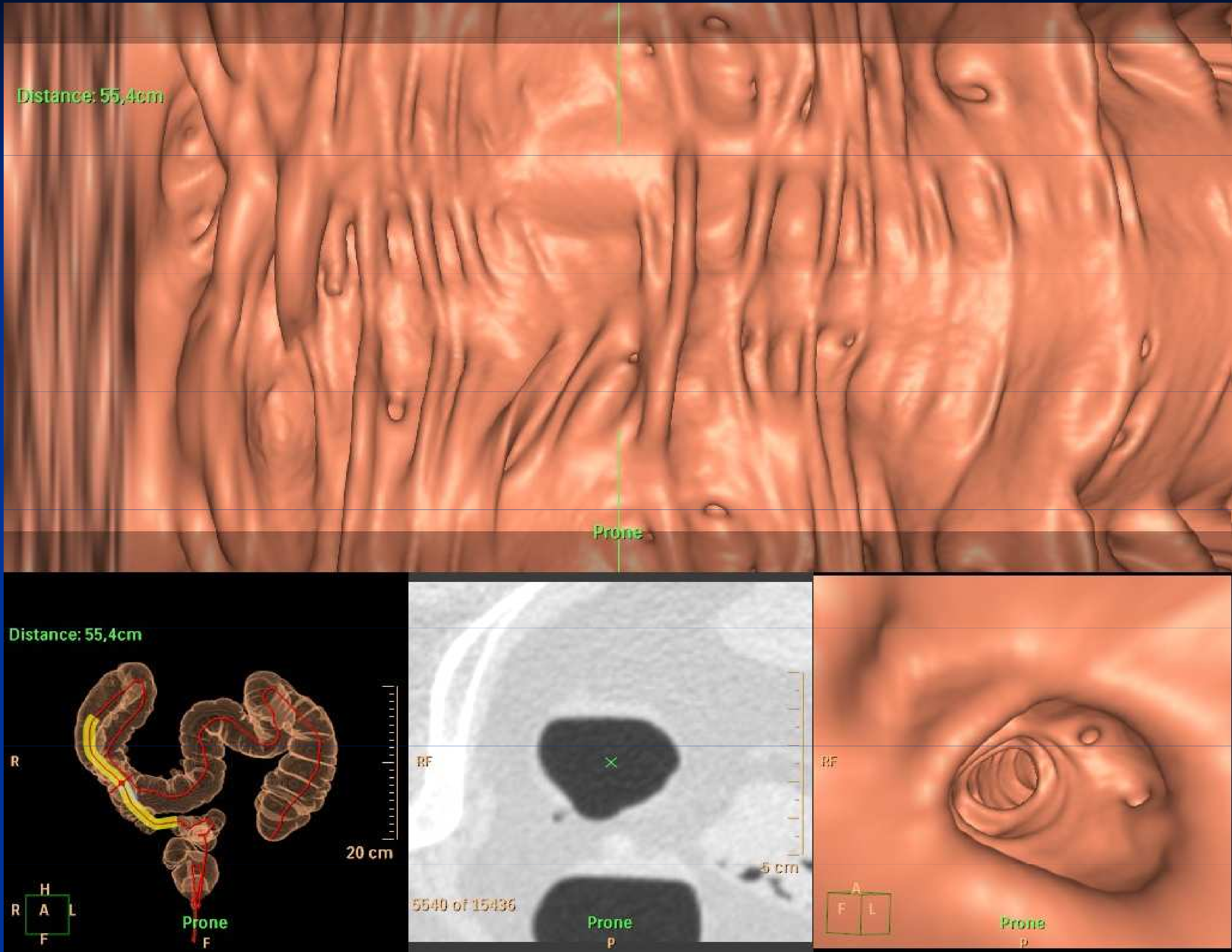


Examination

Classic 2D CT nativ

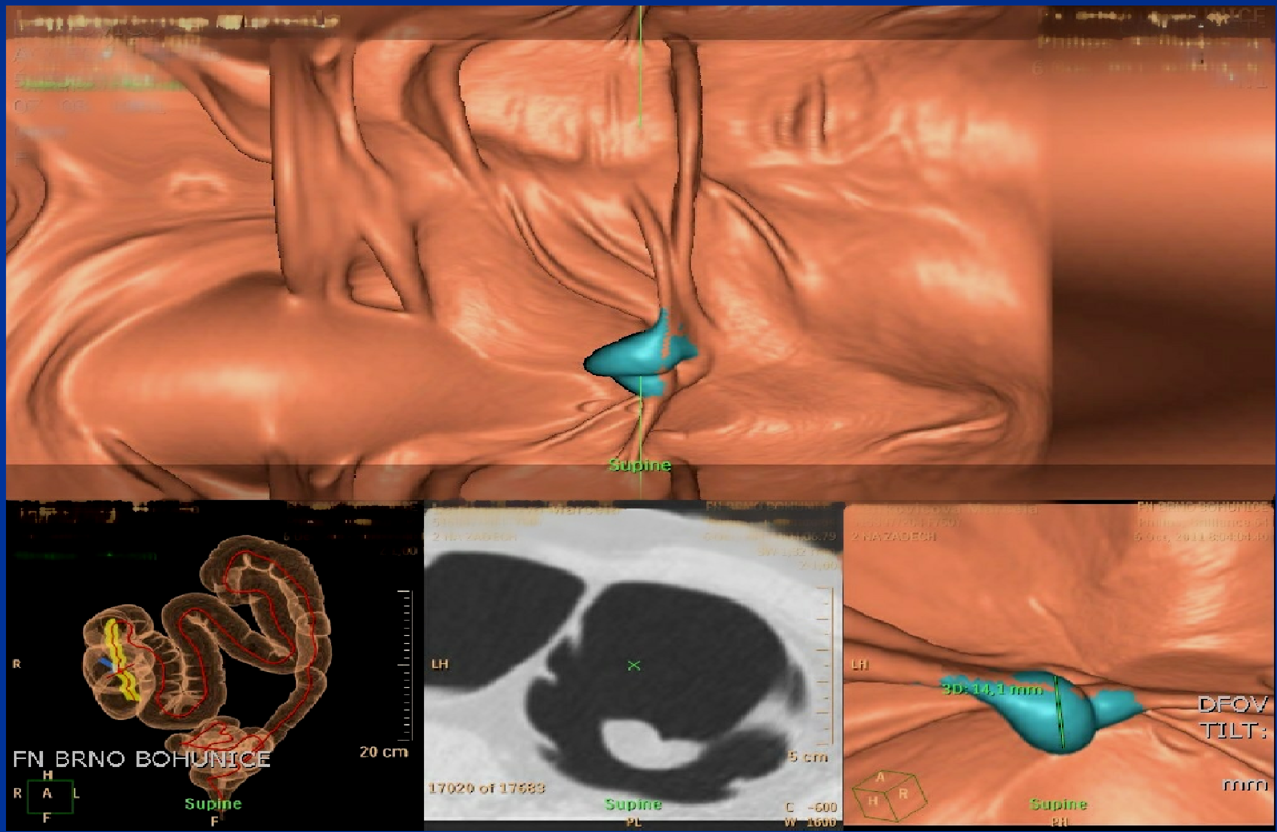
Primary software automatic detection of polyps(CAD)

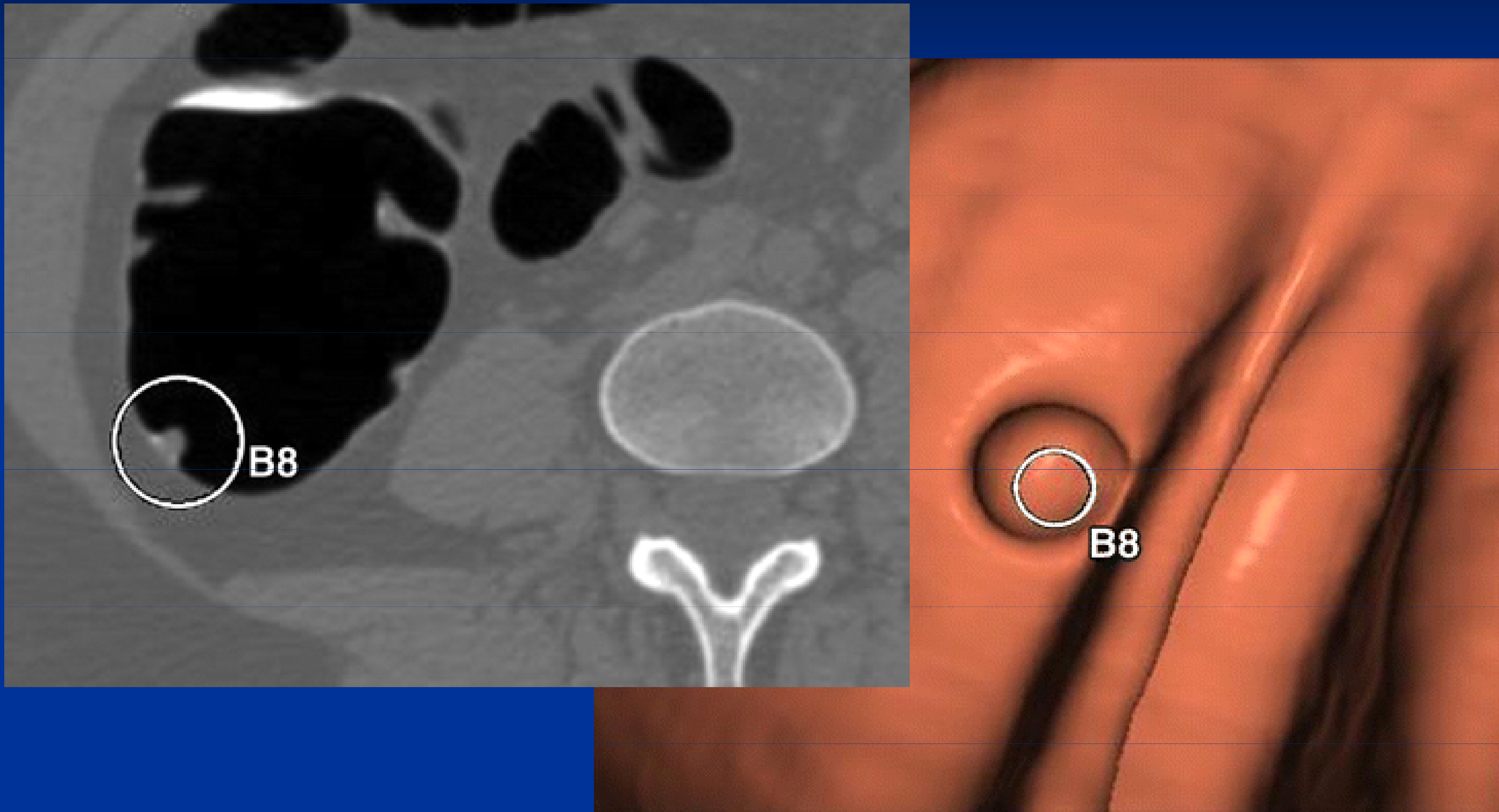
Secundary manual detection in



Distance: 55,4cm
Prone
Distance: 55,4cm
R
20 cm
H
R A L
F
Prone
F
RF
5 cm
5540 of 15436
Prone
P
RF
A
F L
Prone
P

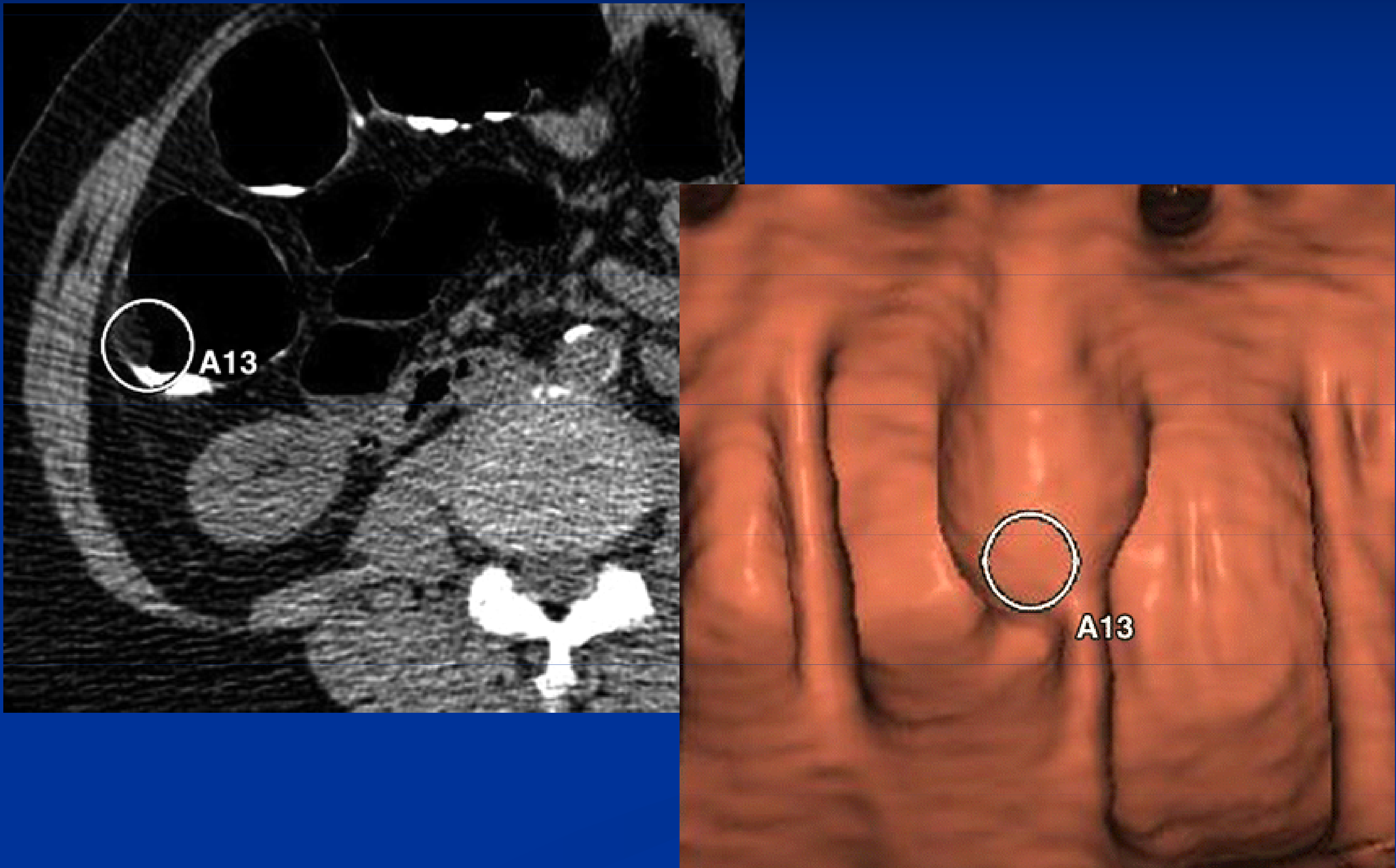
Computer-aided detection CAD

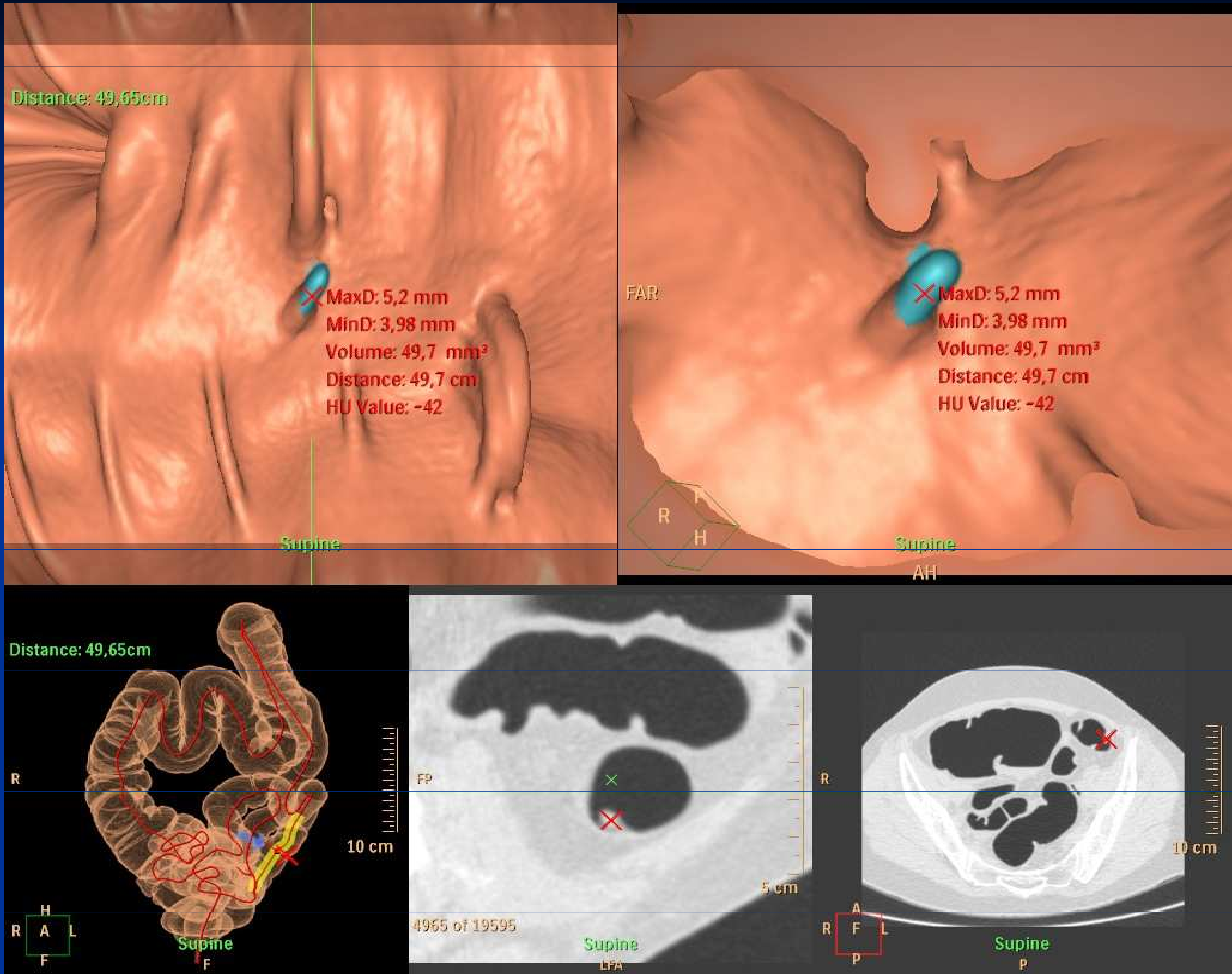




6 mm měkkotkáňový polyp na colon ascendens – malý tubulární adenom

Submucosal lipoma




Distance: 49,65cm
MaxD: 5,2 mm
MinD: 3,98 mm
Volume: 49,7 mm³
Distance: 49,7 cm
HU Value: -42
Supine
FAR
MaxD: 5,2 mm
MinD: 3,98 mm
Volume: 49,7 mm³
Distance: 49,7 cm
HU Value: -42
R
F
H
Supine
AH
Distance: 49,65cm
R
10 cm
H
R A L
F
Supine
F
FP
5 cm
4965 of 19595
Supine
LFA
R
10 cm
A
R F L
P
Supine
P

MRI – New methods

- diffusion-weighted imaging, (DWI)
- diffusion tensor imaging, (DTI)
- Functinal MRI (fMRI)

Spectral CT

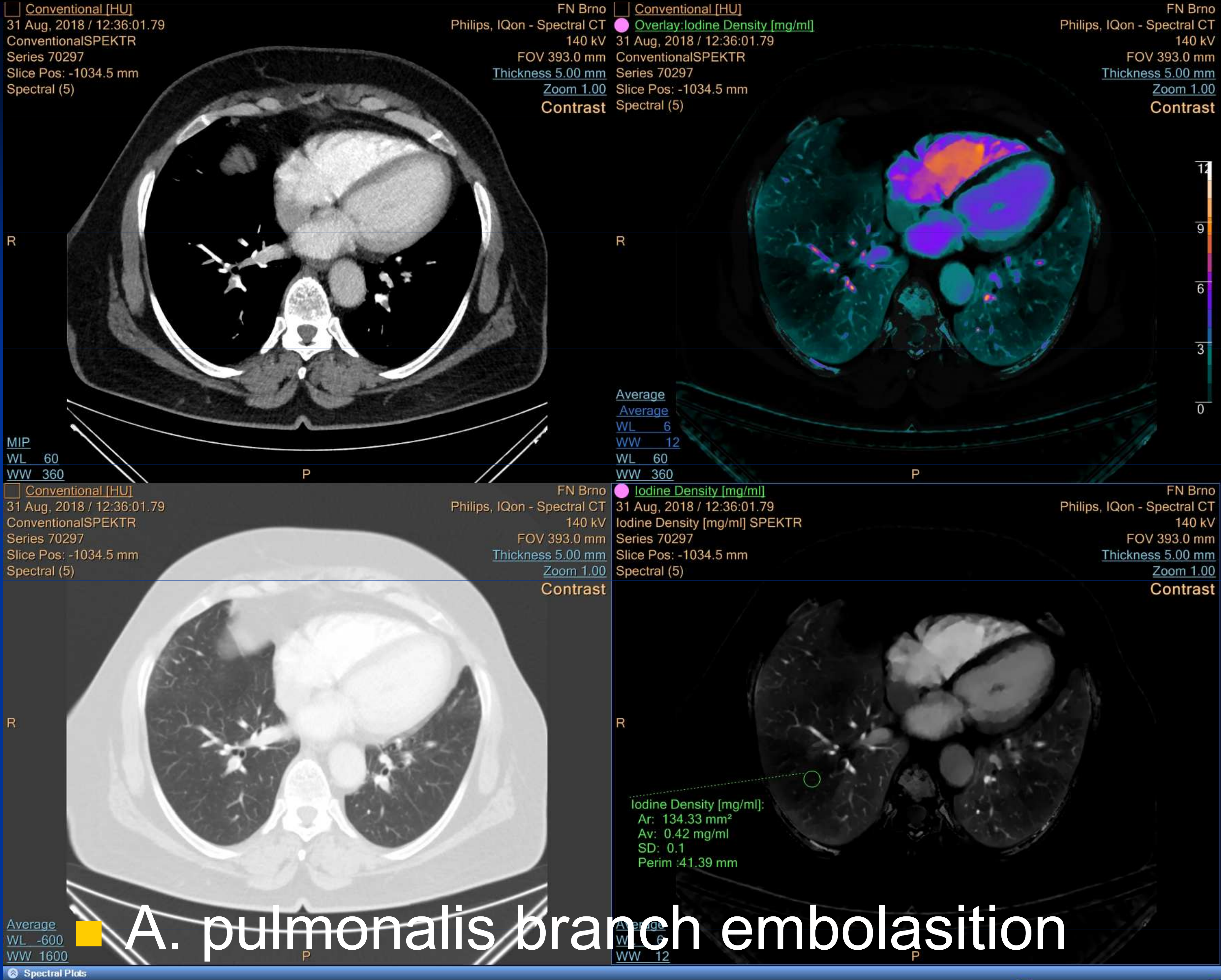
- CT spectral data reconstructed using Compton scattering and photoeffect information is stored in SBI (Spectral Based Image)

- spectral data results can be displayed as normal grayscale CT or color map.

- pixel intensity may correspond to:
  - HU
  - concentrations of the material (mg / ml), e.g. iodine
  - effective atomic number (Z_{eff})

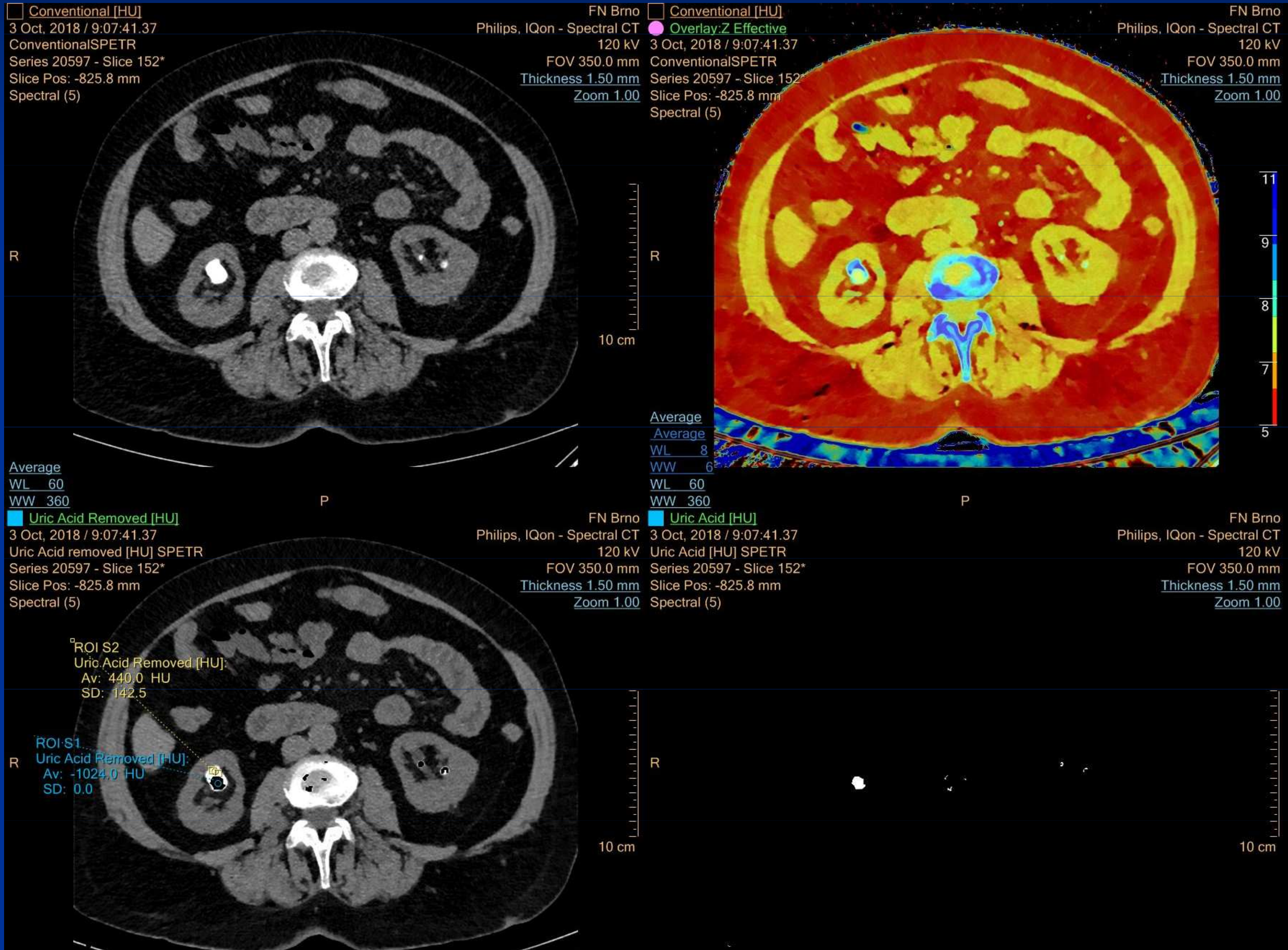
Spectral CT usage

- Perfusion maps in diagnosis of a.pulmonalis embolisation
- Spectral analysis of urinal stones
- Detection of hypervascular leasions(e.g. In liver):



- A. pulmonalis branch embolasition

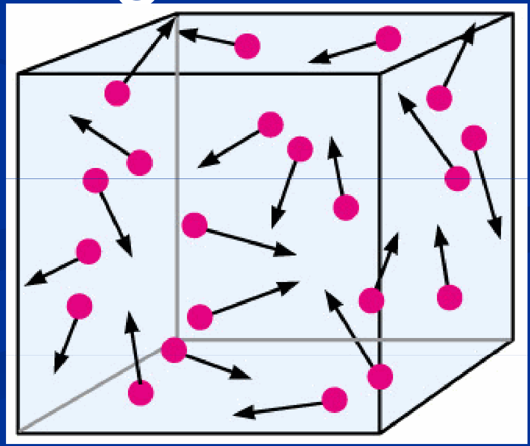
Mixed urinary stone

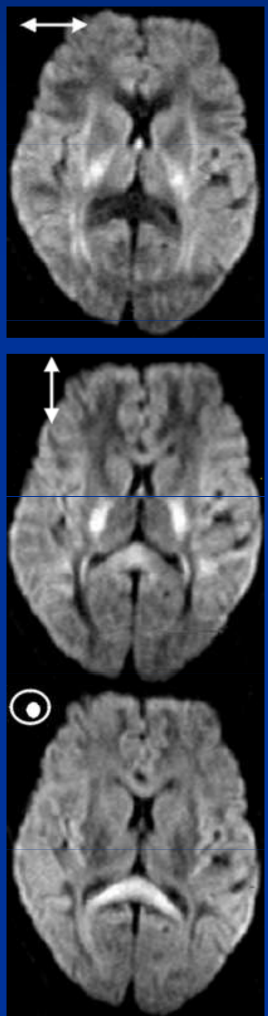


DWI: Diffusion weighted imaging

- Difusion – random motion of water molecules in tissue (Brownův pohyb)

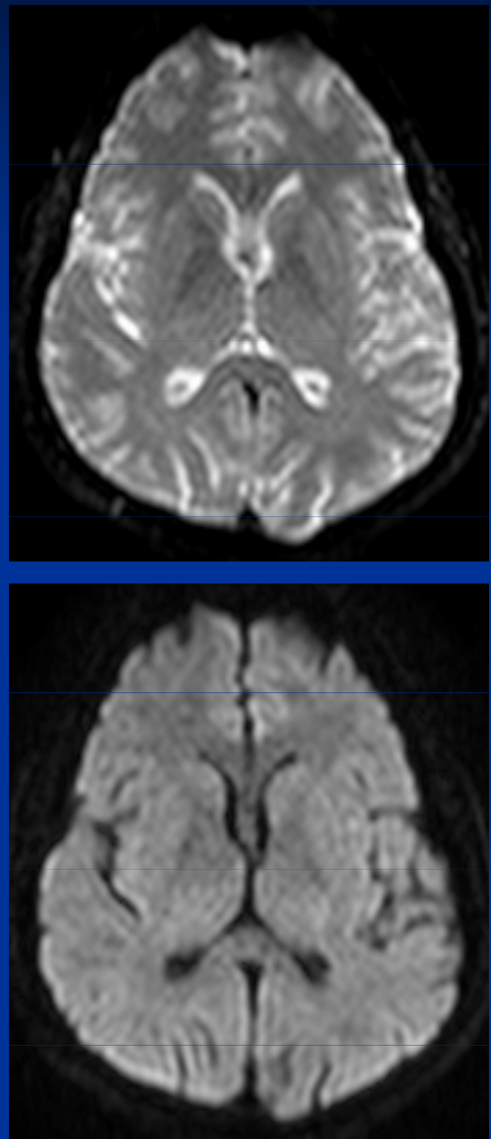
- Alteration of the process of diffusion is characteristic for certain pathological conditions





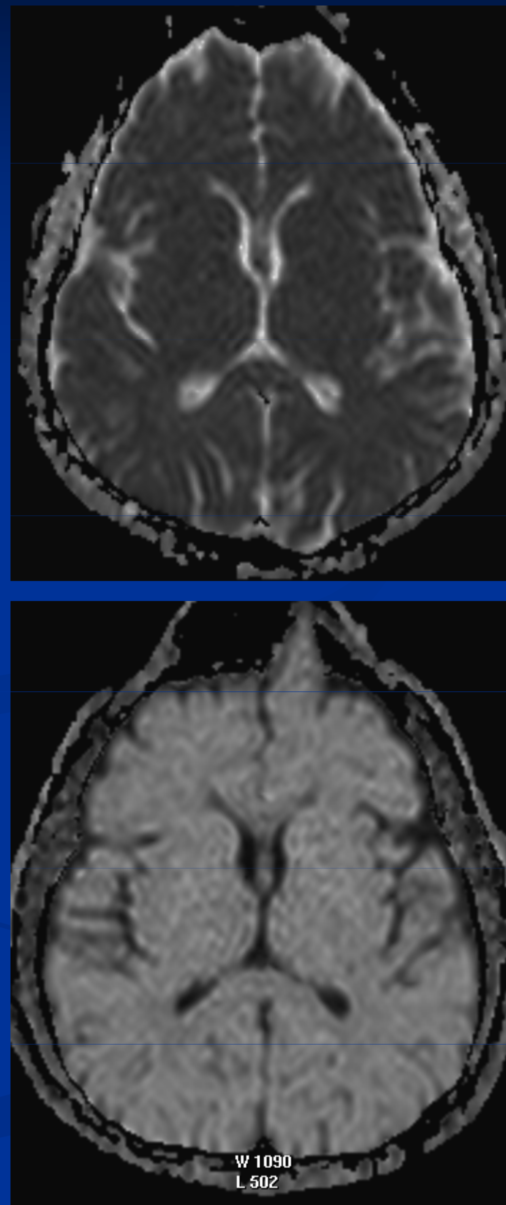
- DWI b1000 anisotropic

- DWI b0



- DWI b1000 isotropic

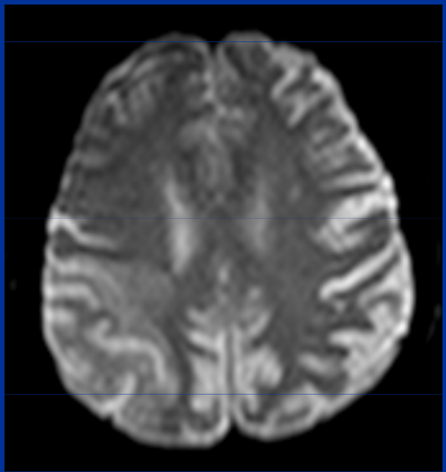
- ADC



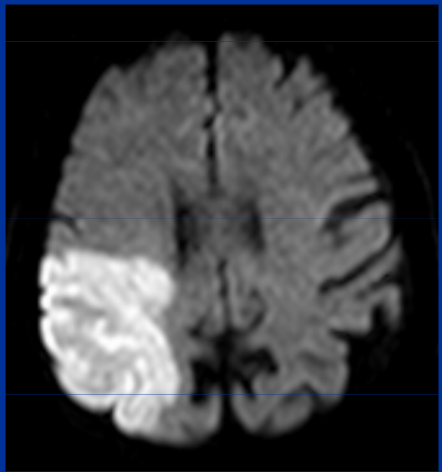
- eADC

Interpretation of DWI

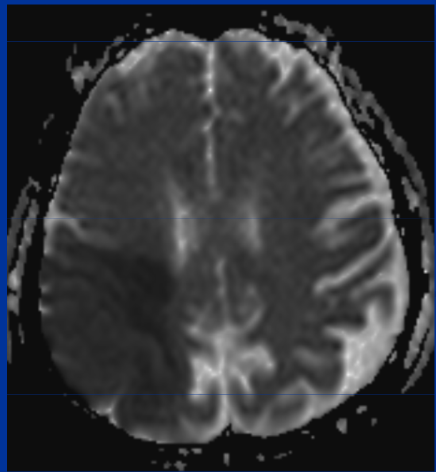
- Restriction od difusion:
  - Hyperintens DWI B1000
  - Hypointens na ADC



DWI B0 = T2



DWI B1000



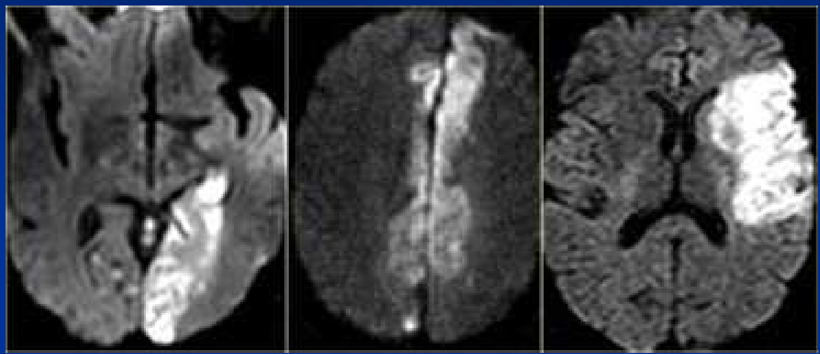
ADC

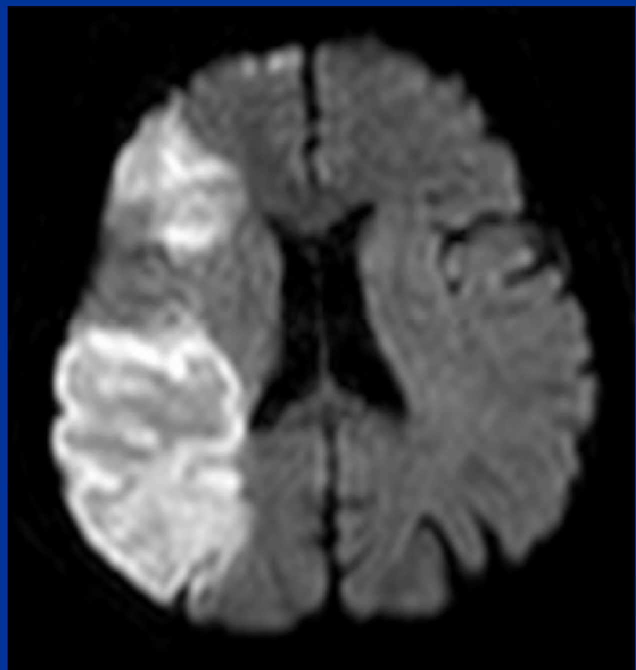
eADC

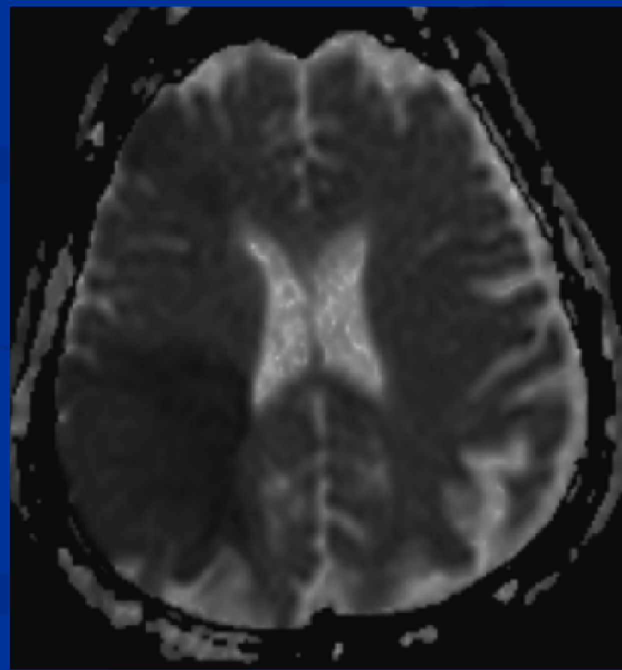
Indications and practical use of DWI

- Detection of early ischemia, and differentiation from tumors
- Differential diagnosis of ring lesions
- More accurate differential diagnosis of tumors.

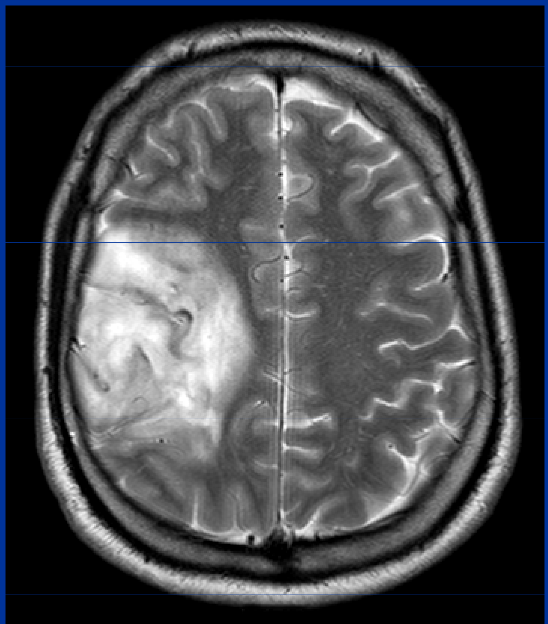
Ischemia on DWI



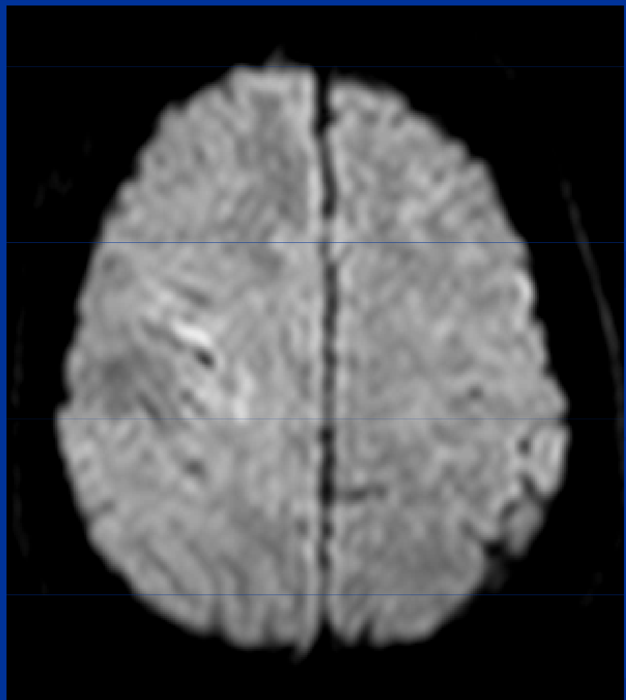




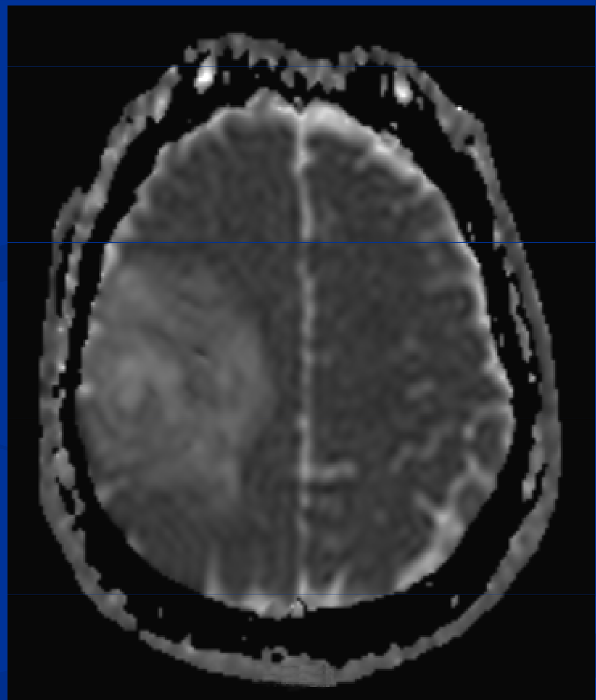
Ischemia x tumor



T2 TSE tra.



DWI B1000



ADC

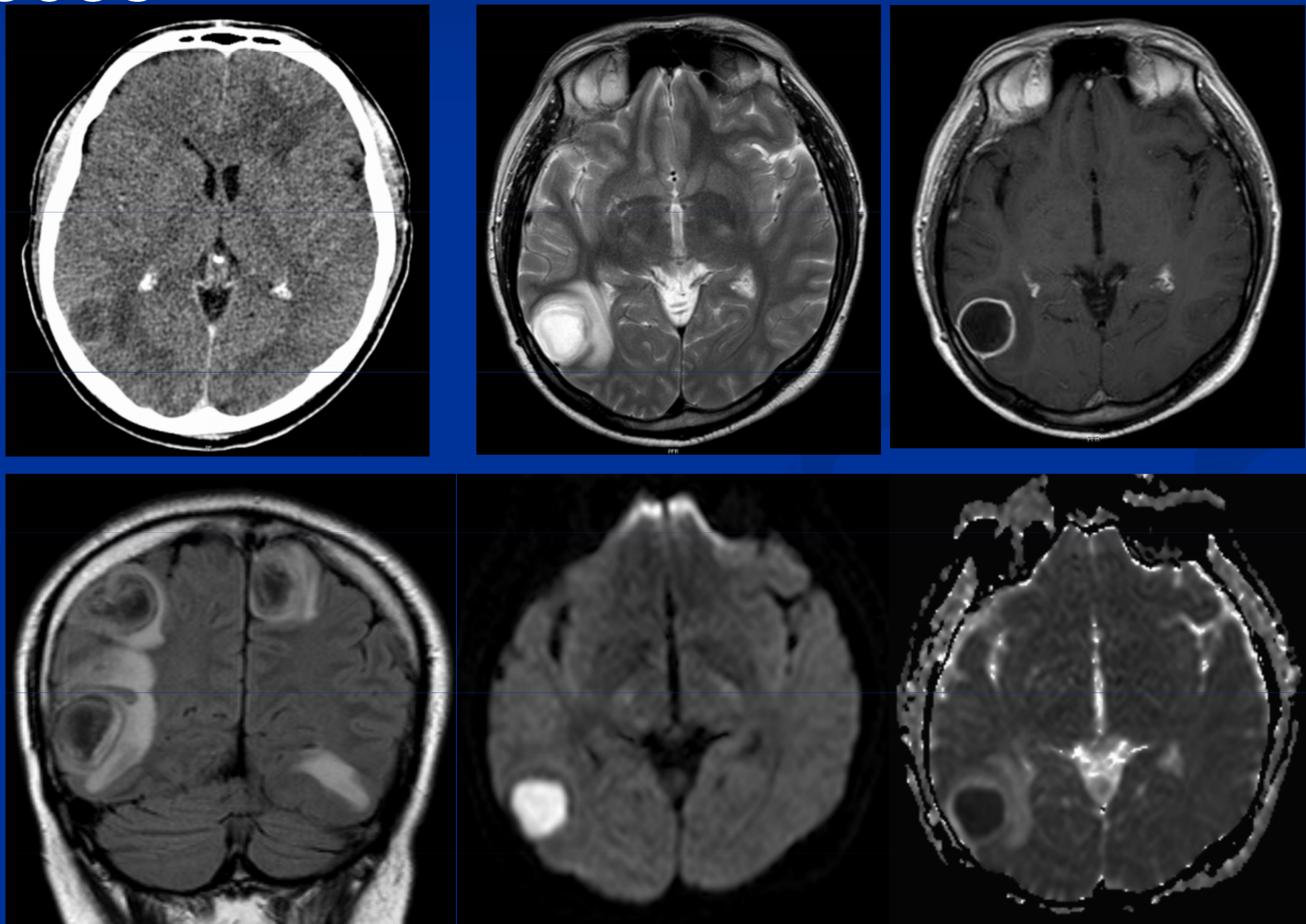
Dif. dg. of ring lessions

- Absces – restriction of diffusion: ↓ADC
- Tumors – facilitacion of diffusion - necrotic centre: ↑ADC

Dif. dg. Ring lessions

- Absces

CT k.l. | T2 TSE tra. | T1 SE k.l. tra.

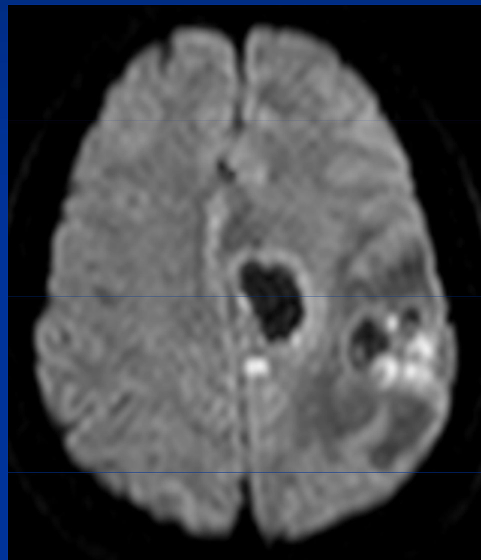


FLAIR cor. | DWI b1000 | ADC

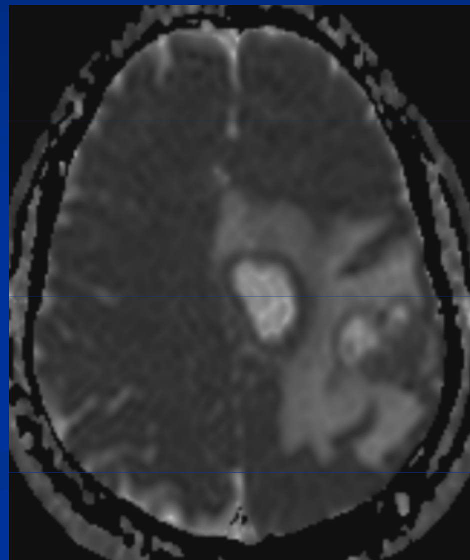
Dif. dg. Ring lessions

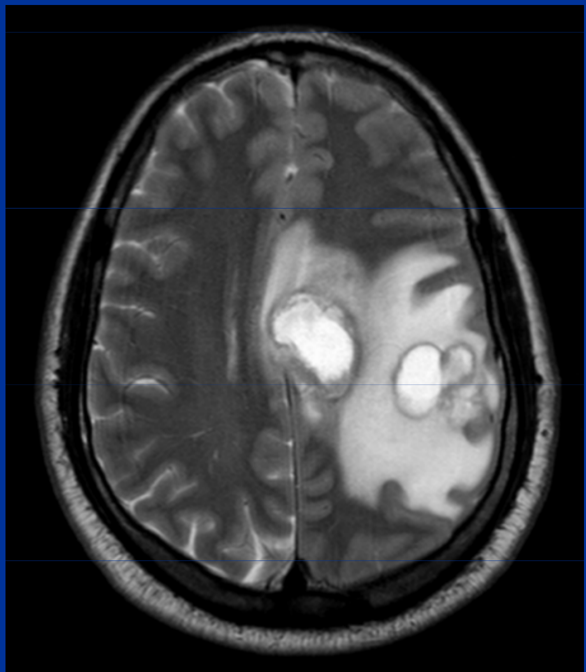
- Metastasis lung adenokarcinoma

▪DWI b1000



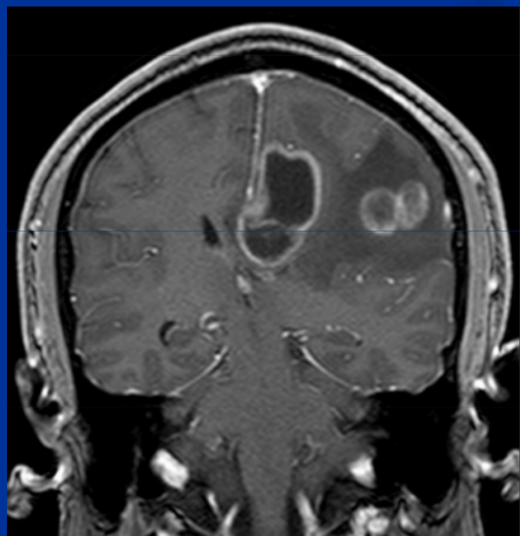
▪ADC

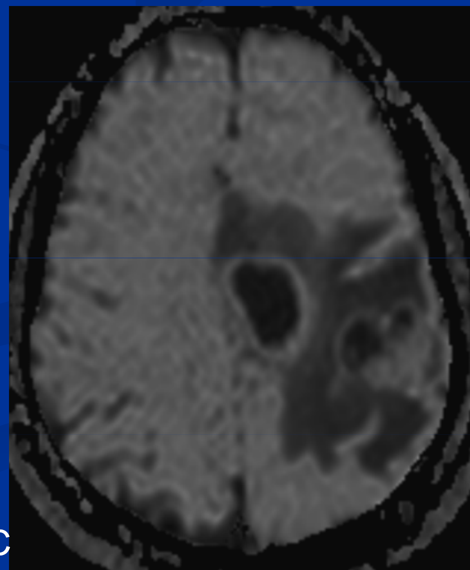




▪T2 TSE tra.

▪T1 SE k.l. cor.





▪eADC

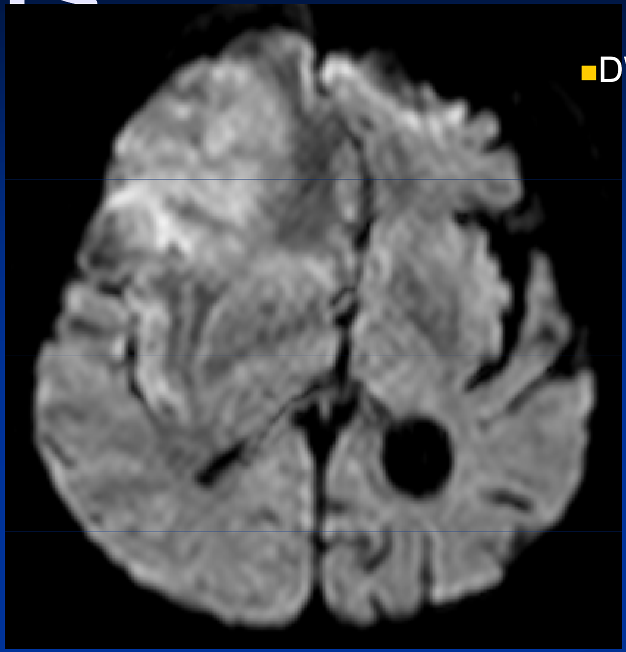
Dif. dg. of tumors

- DWI image depence on the histological structure of the tumor tissue: diffusion decreases with increasing cellularity, (↓ADC) lymfoma, high-grade glioma

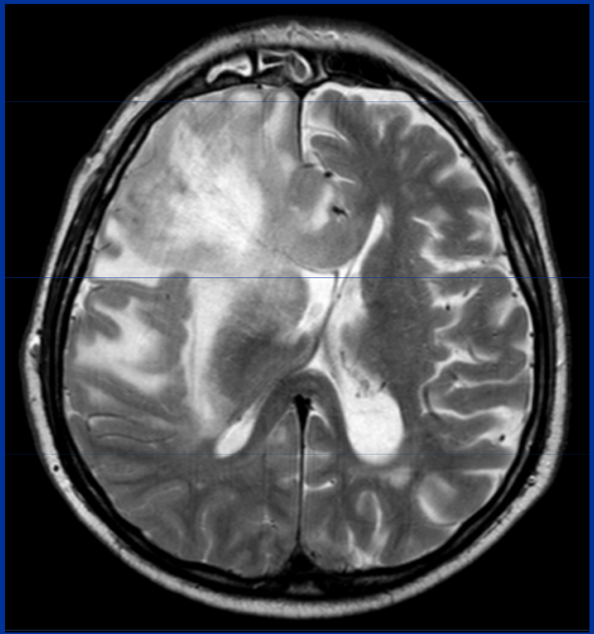
  - High ADC value - low-grade glioma – low cellularity

Dif. dg. tumors

- Lymfoma

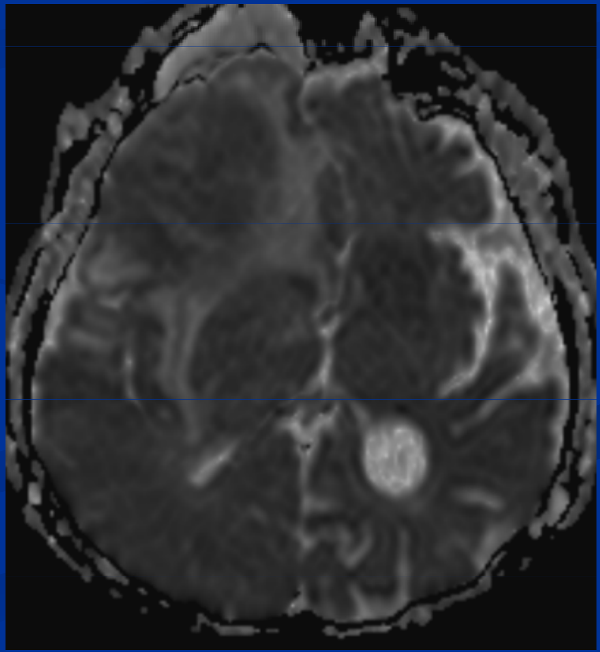


DWI b1000



T2 TSE tra.

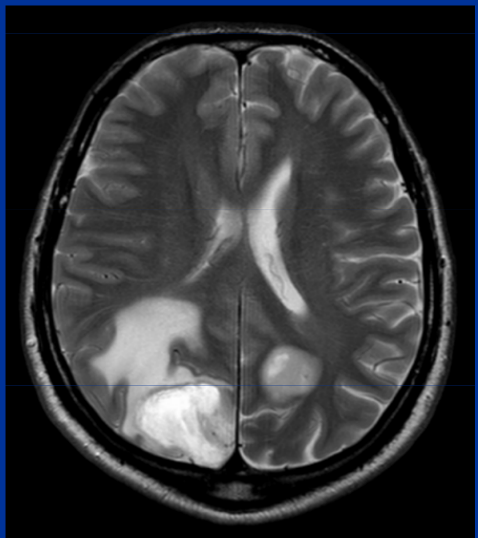
T1 SE k.l. sag.



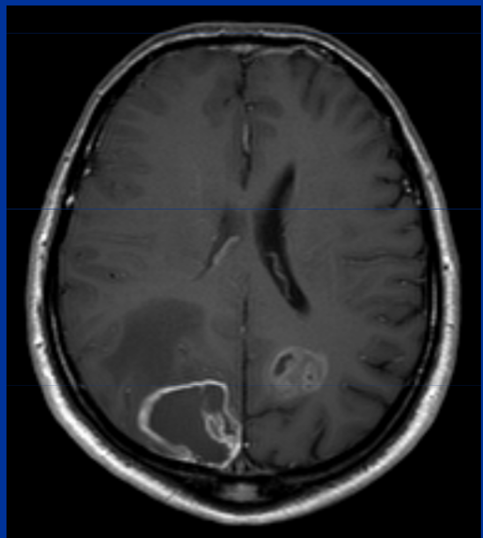
ADC

Dif. dg. tumors

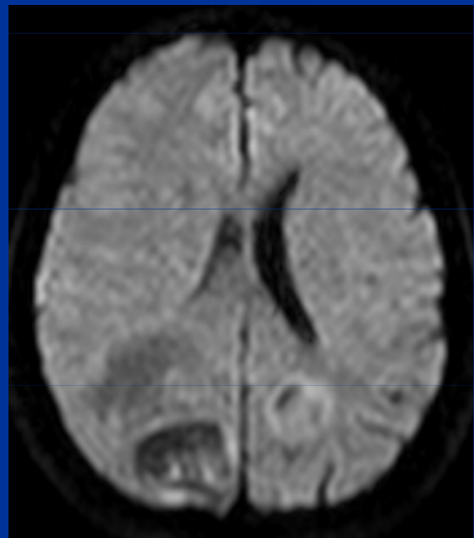
- High-grade glioma



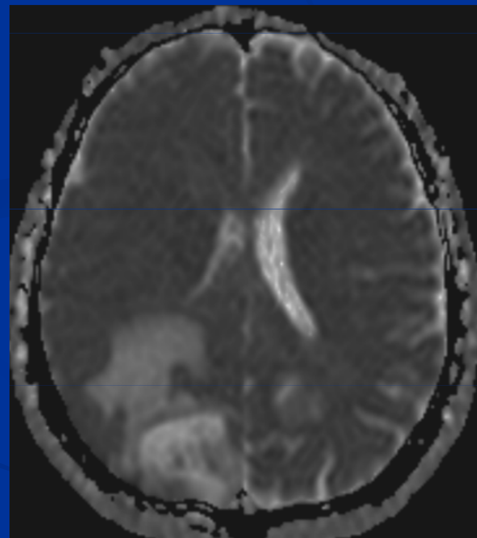
▪T2 TSE tra.



▪T1 SE k.l. tra.



▪DWI B1000



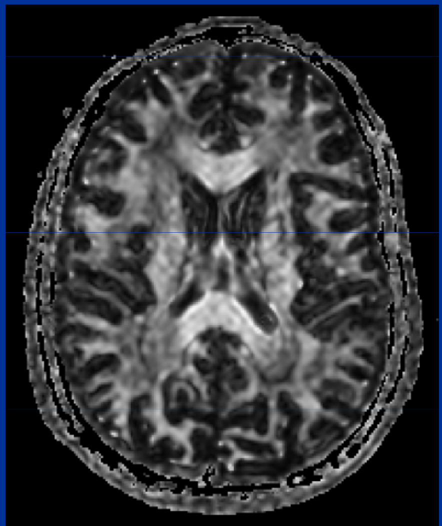
▪AD
C

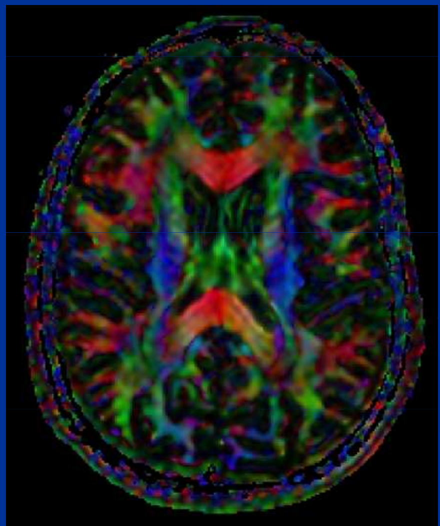
DTI – diffusion tensor imaging

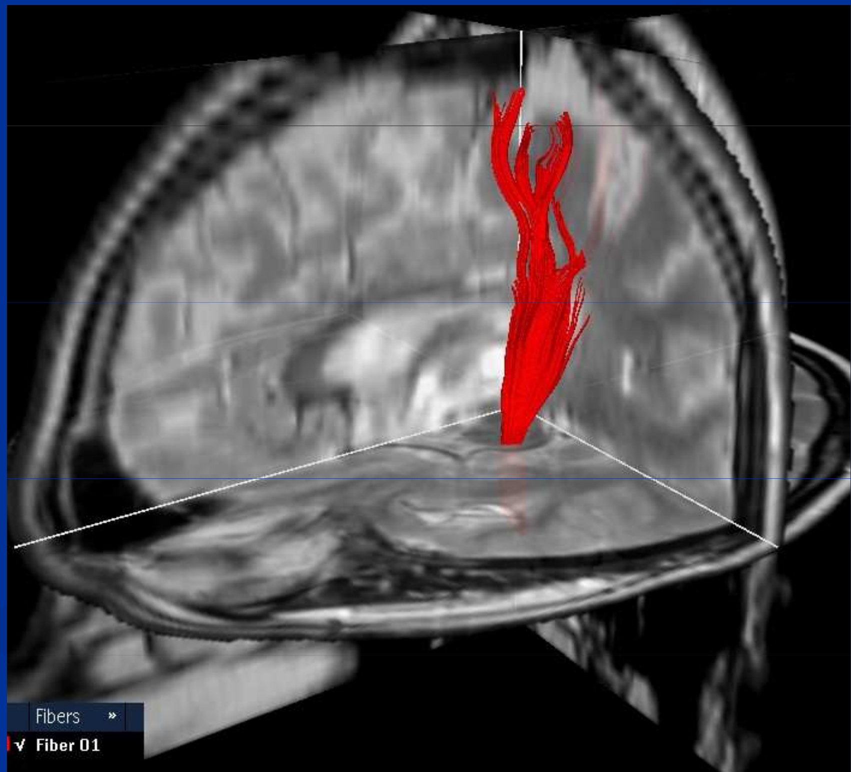
- Method based on the principles of DWI
- Diffusion anisotropy in the white matter of the brain and spinal cord: the movement of water molecules occurs more easily along the nerve fibers
- DWI image signal intensity depends on the direction of the magnetic gradient adjunctive
- Repeated measurements with different directions of diffusion can detect the dominant direction of diffusion direction → During nerve pathways for example

DTI

- processing:
- Map of fraction anisotrophy
  - Directionally coded map of vectors of diffusion anisotropy
  - 3D Fibertracking





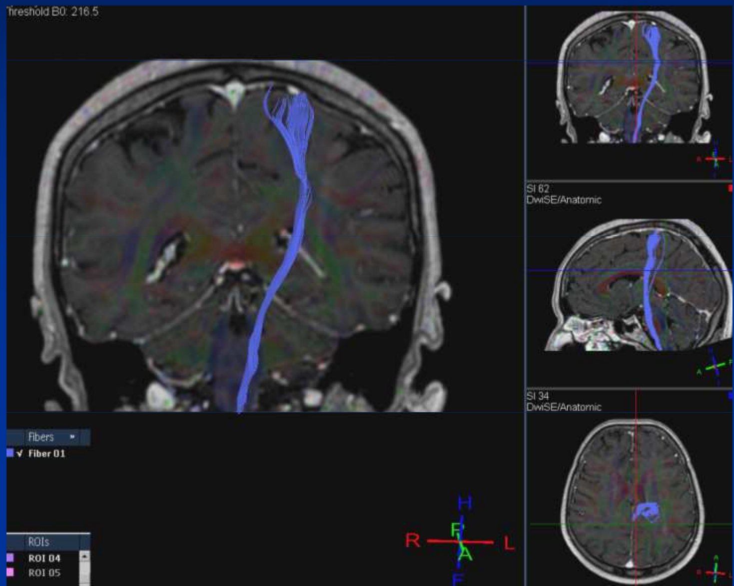


DTI - usage

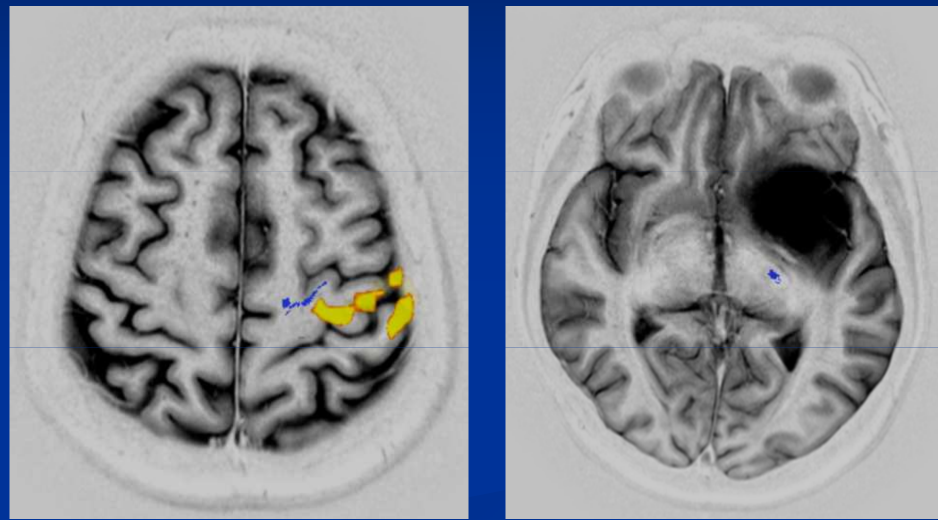
- Measurement of fractional anisotropy and ADC evaluation for impairment of white matter:
  - Normal white matter - the maximum diffusion along the long axis of the nerve bundles
  - Abnormal white matter - an increase of diffusivity of water molecules throughout the nerve tracts → reduce diffusion isotropy
    → DTI has the potential for earlier detection of pathology of white matter than conventional display

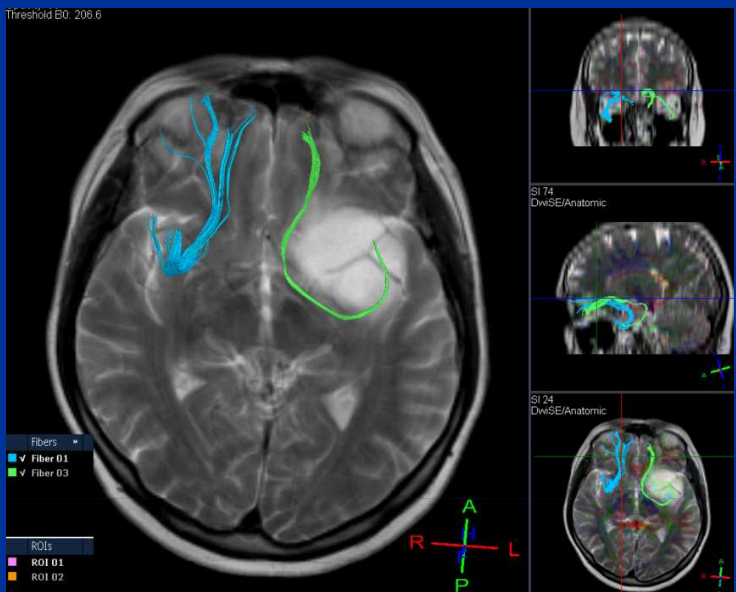
3D fibertracking - displaying of neural pathways eg. To assess the relationship to tumor

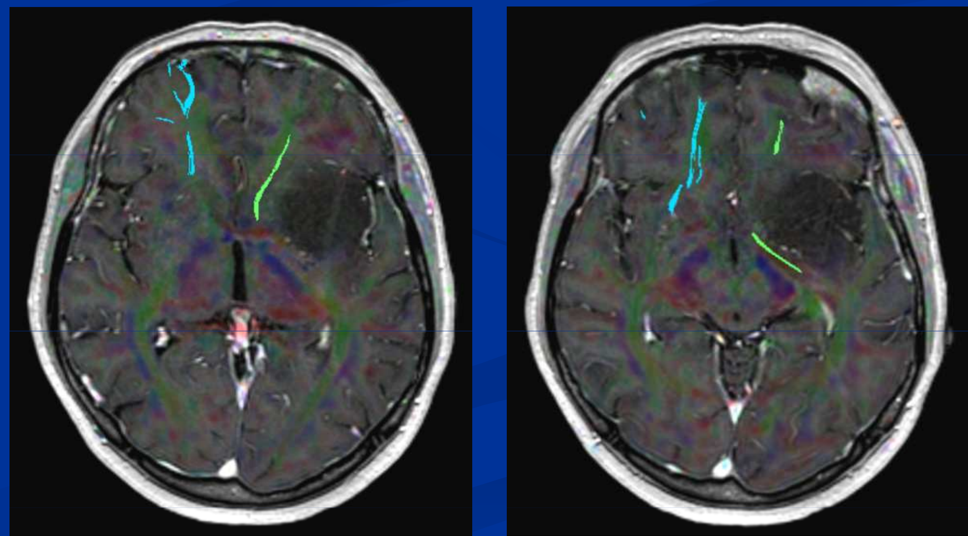
DTI fibertracking: glioma gr. II



■ Tractus corticospinalis



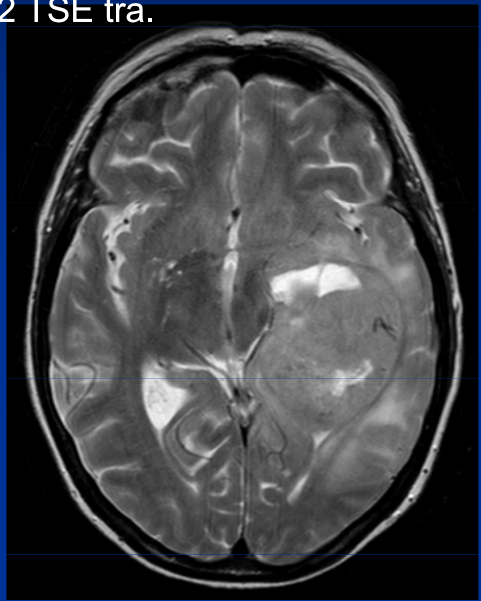




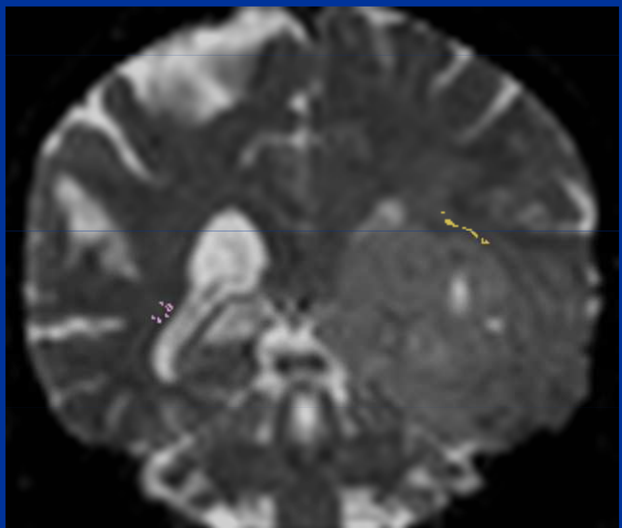
■ Fasciculus uncinatus

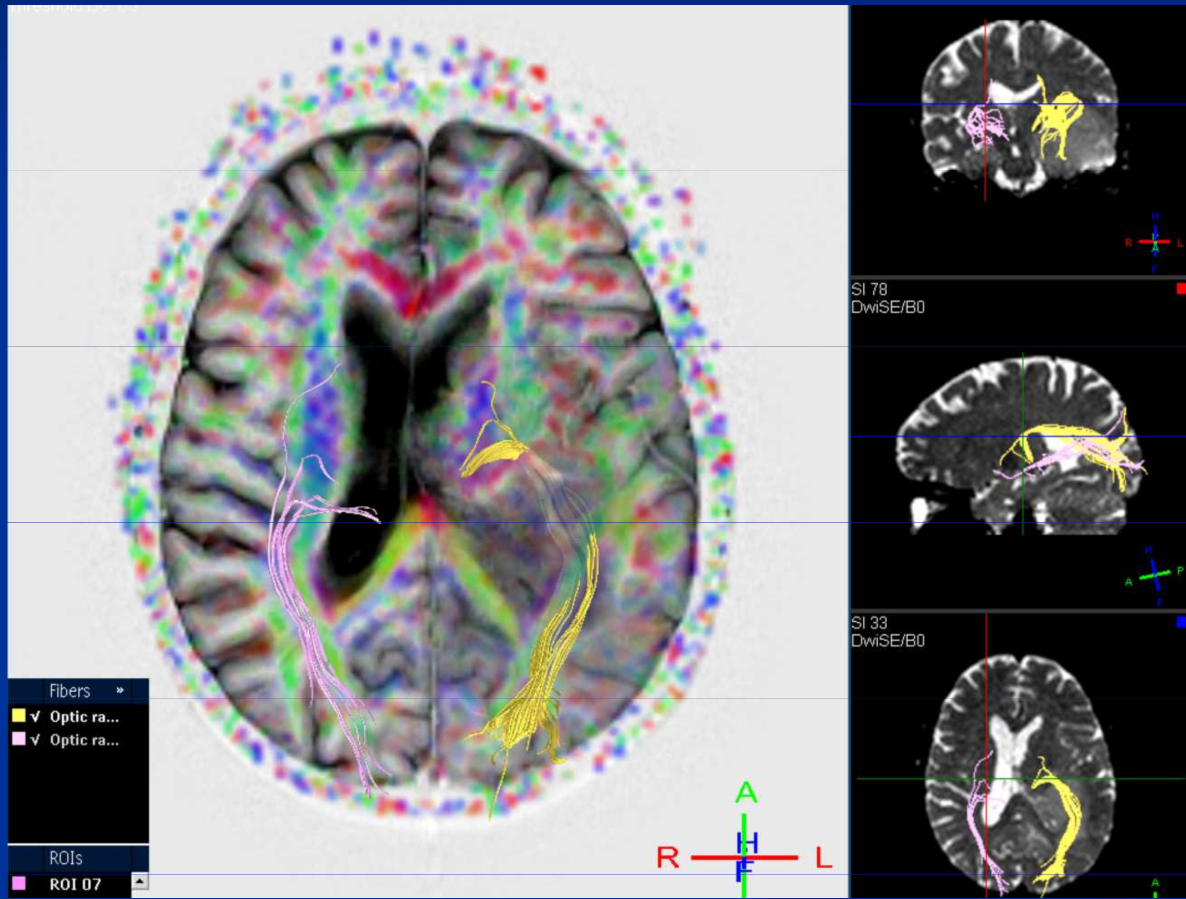
DTI fibertracking: glioma gr. III

- T2 TSE tra.



- DWI b0 cor.





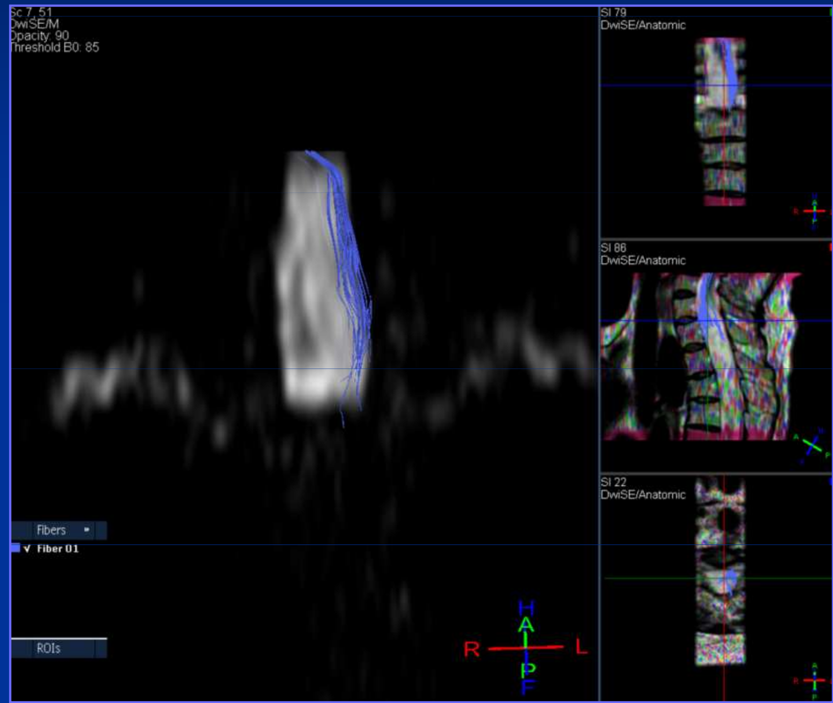
- Radiatio optica

DTI fibertracking: metastasis

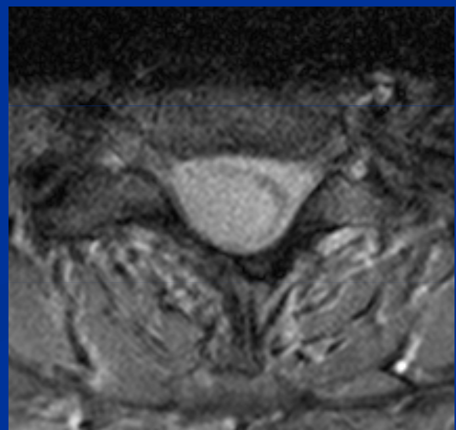
- Tractus corticospinalis

DTI fibertracking: spine tumor

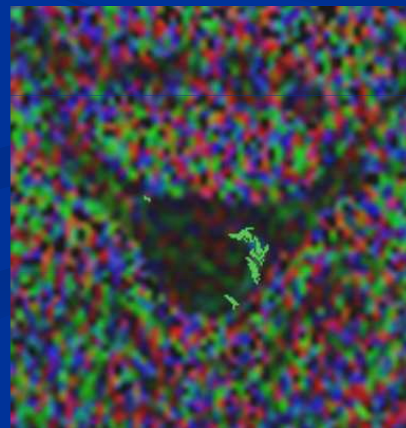
- T2 TSE sag.



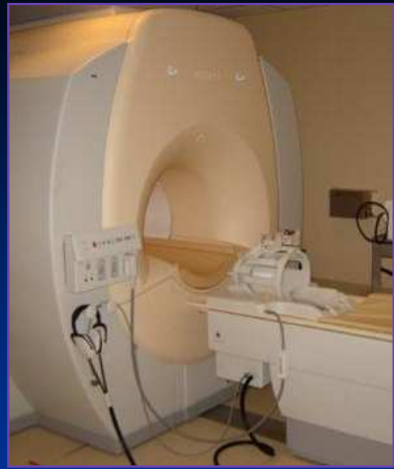
- T2 FFE tra.



- mapa FA



Fuctional MRI (fMRI)

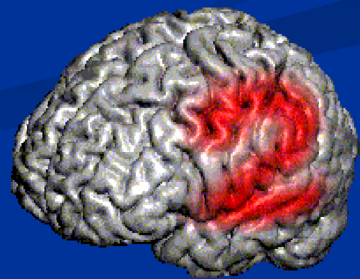


One of the modern applications of magnetic resonance imaging

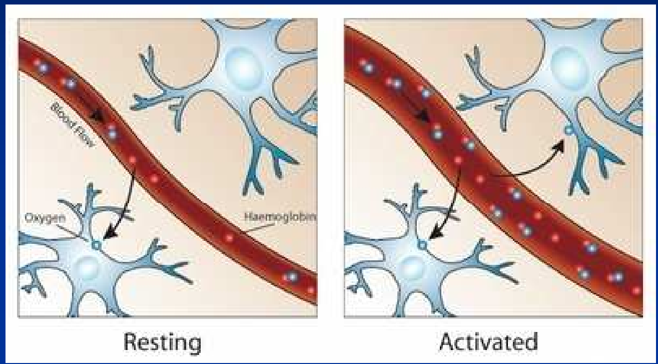
Allows direct display of functionally active cortical areas

Totally non-invasive examination, relatively easy for patients

What can be displayed: motor functions, auditory and visual centers, memory, speech and cognitive functions, emotions…



Bold efekt

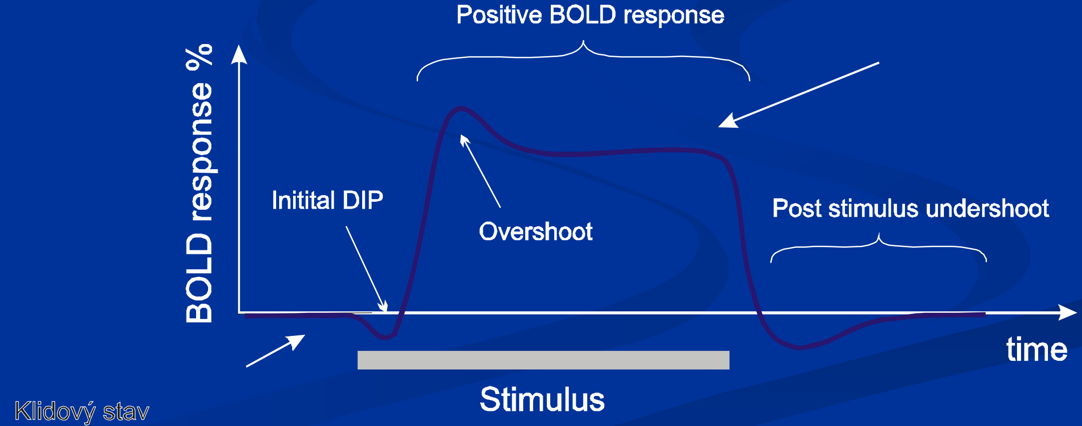


Blood oxygen level dependency(BOLD):

The basic principle of fMRI

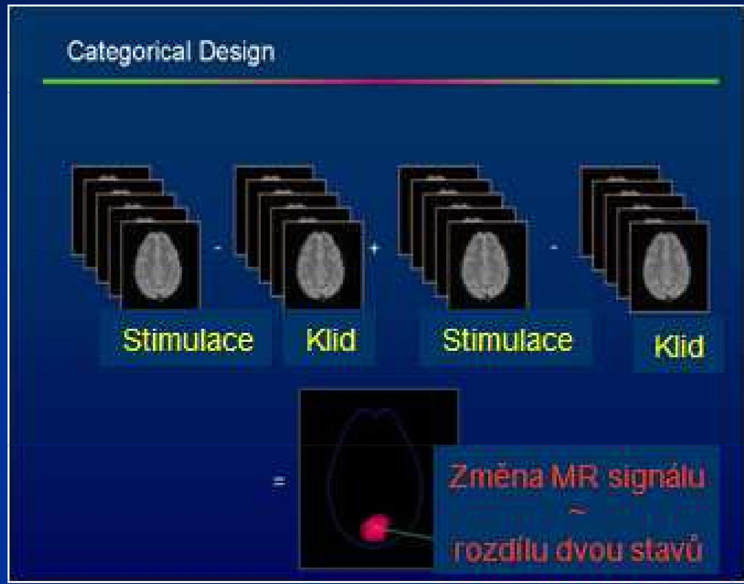
The dependence of the MR signal intensity on the ratio of oxyhemoglobin / deoxyhemoglobin

- Kortical activity:
  - Transient increase in the concentration deoxyHb → decrease in T2 * signal
  - vasodilation with increased blood flow → ↓ deoxyHb and increase in T2 * signal



fMRI examination

- Examination of the entire brain
- multiply repeated
  a certain kind of activity (finger movement, speech ..)
  alternating with the rest sections



- Statistical analysis reveals a difference in signal intensity in different areas of the brain by comparing blocks of stillness and blocks of activities

Indication of fMRI

- Preoperative mapping of functional cortical centers
- Assessment of functionally important areas related to tumor

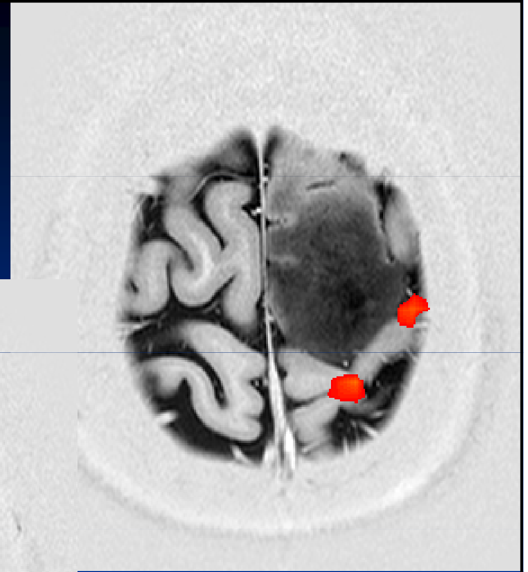
■FMR

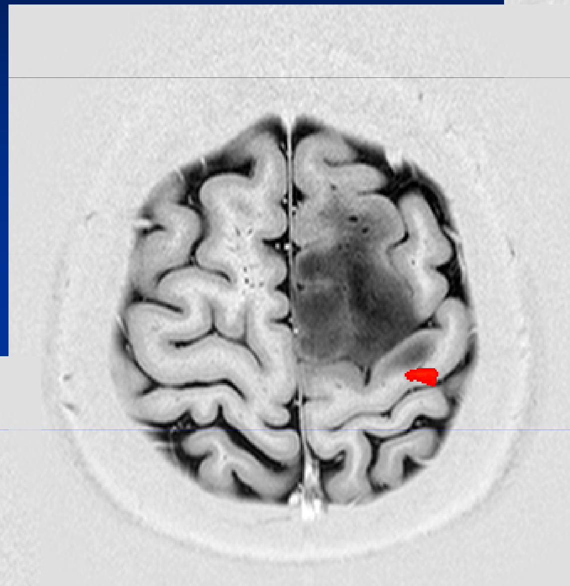
low-grade glioma

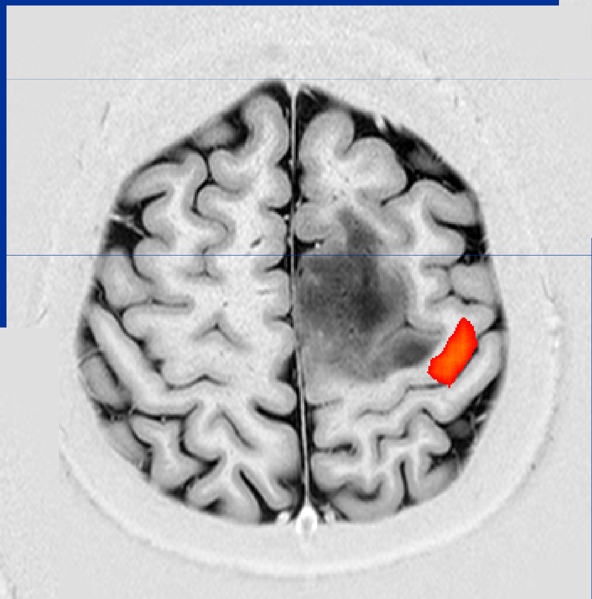
■Finger of right hand movement

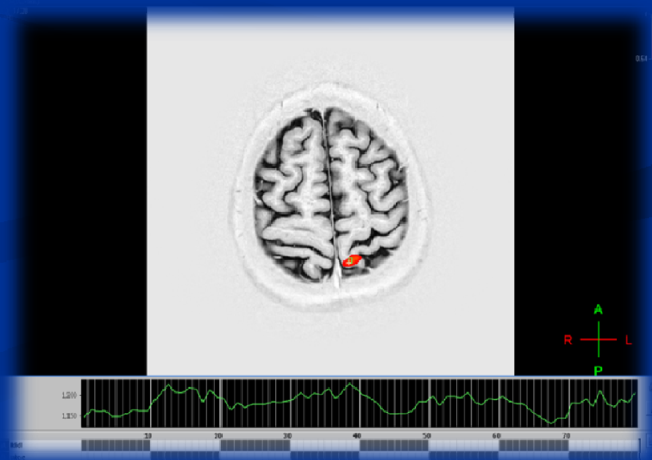
■Sekvence

- Single shot EPI
- TR 3000ms, TE 50ms
- 80 dyn. akvizic
- Overlay statistických map na referenční sken T1 true IR

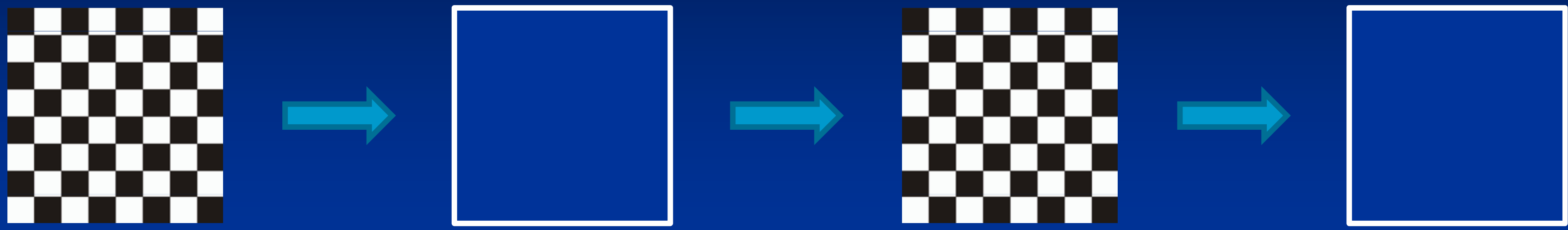








fMRI – visiom kortex



fMRI use in preoperative planning

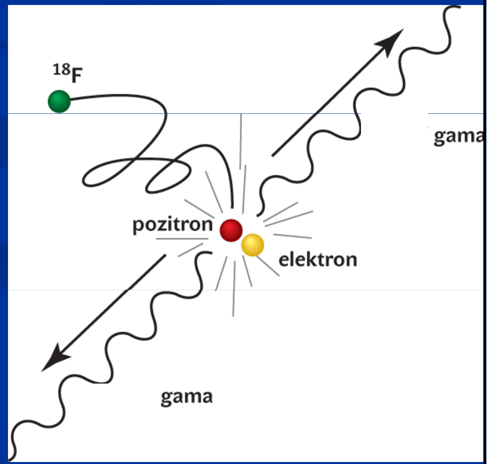
- Rule of fMRI:
  - determination of lateralization of speech
  - Preoperative view of eloquent cortical areas related to tumor
  - Peroperativ navigation of stimulating electrods

PET/MR

- Hybrid method
- Positron emission tomography
- Magnetic resonance
- 1 device – MR + PET

PET

- Tomographic method, three-dimensional mapping of radioactivity
- Principle - detection of photons(gama radiation) - during annihilation of positrons and electrons
- Positron - radiopharmaceutical - short half-life - beta + decay
- Two 511keV photons - two registration at one time
- Detectors - ring - coincidence connection
- Activity at individual points



Radiopharmaceuticals

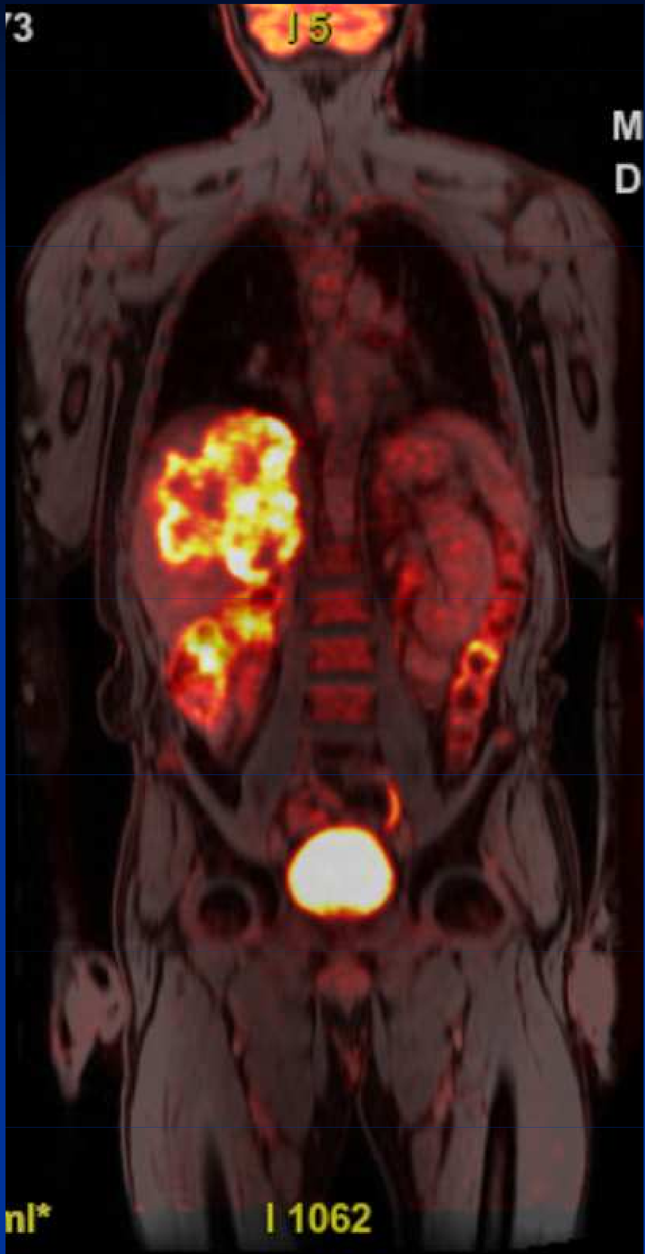
- 18FDG – aerobic glycolysis
- 18FLT – fluorothymidin - cell proliferation
- Na18F – bone recovery
- 18Fcholin – prostate carcionoma
- 18Fflutemetamol – brain Alzheimer disiese
- 68Ga DOTA– neuroendocrinal tumors

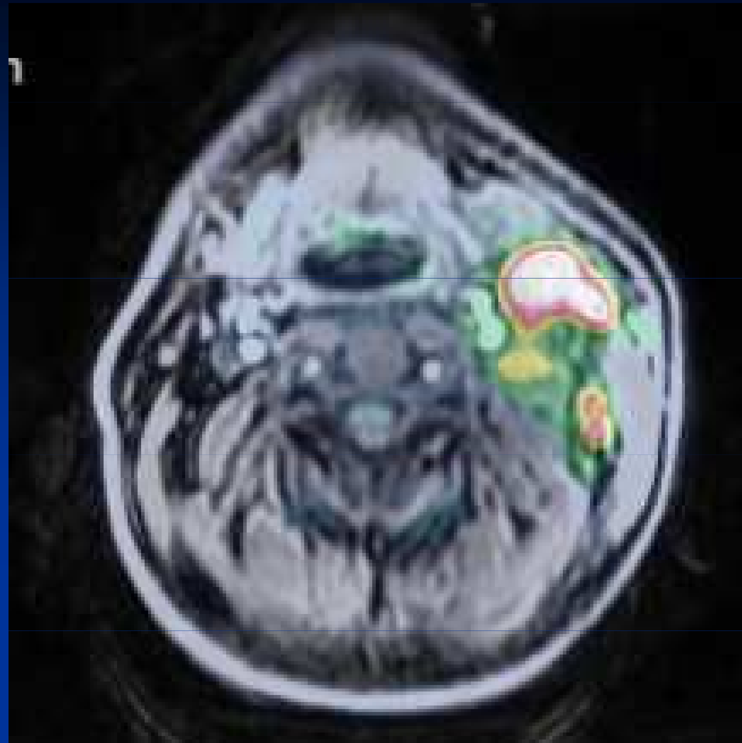
Indication

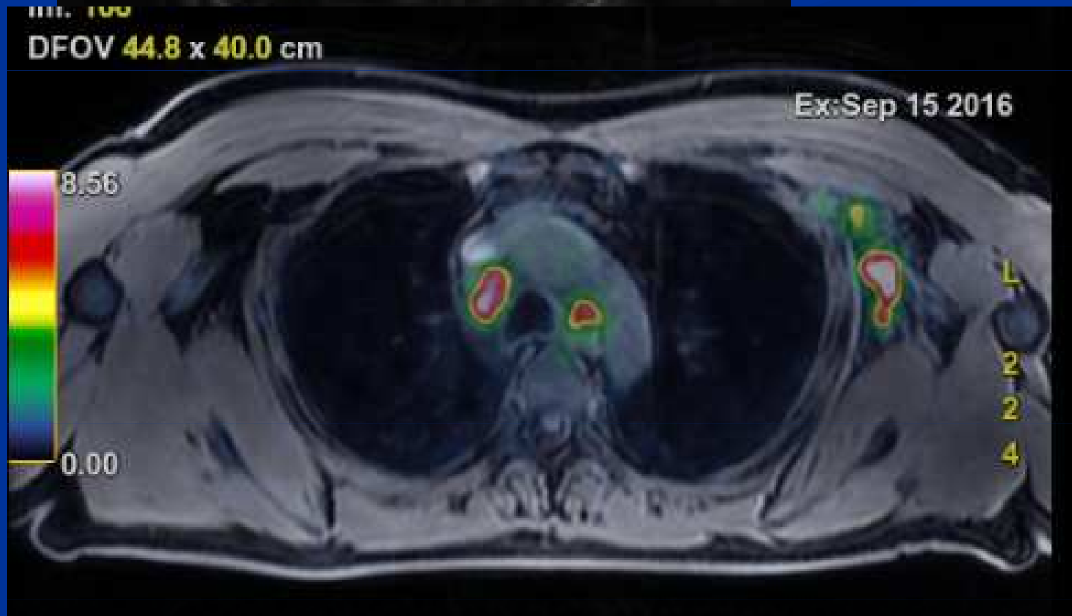
- Oncology (staging, control of treatment effectiveness, monitoring after treatment)
- Inflammation (investigation of inflammation origin, vasculitis, sarcoidosis, inflammation of the heart, suspected inflammatory changes around implanted foreign materials
- Rheumatology (eg polymyalgia)
- Cardiology - myocardial viability
- Endocrinology (detection of hyperfunctional parathyroid glands)
- Non-tumorous pathology of CNS (Neurodegenerative diseases)

Benefits of PETMR x PETCT

- No radiation load x CT
- PETCT – mean dose 5 - 23 mSv, PET 3-5 mSv
- Excellent tissue contrast MR
- Possibility to combine with more advanced techniques such as perfusion, DWI, angiography, spectroscophy
- Disadvantage the length of the examination and basic MRI contraindications







- Metastais in liver CA of rectum

- lymfoma