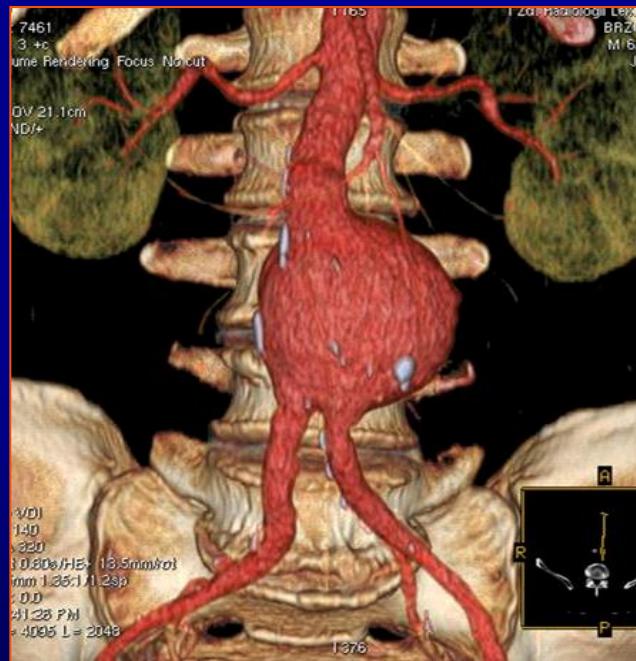


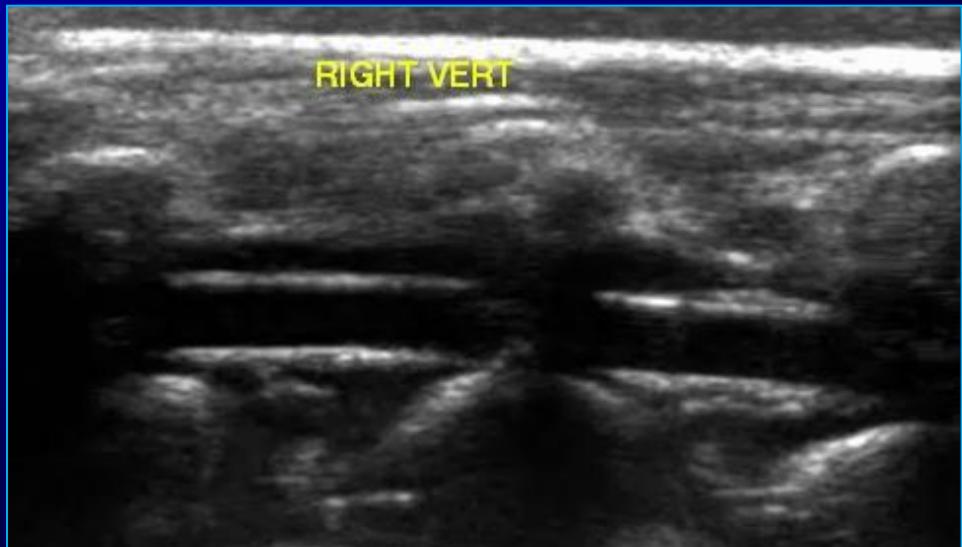
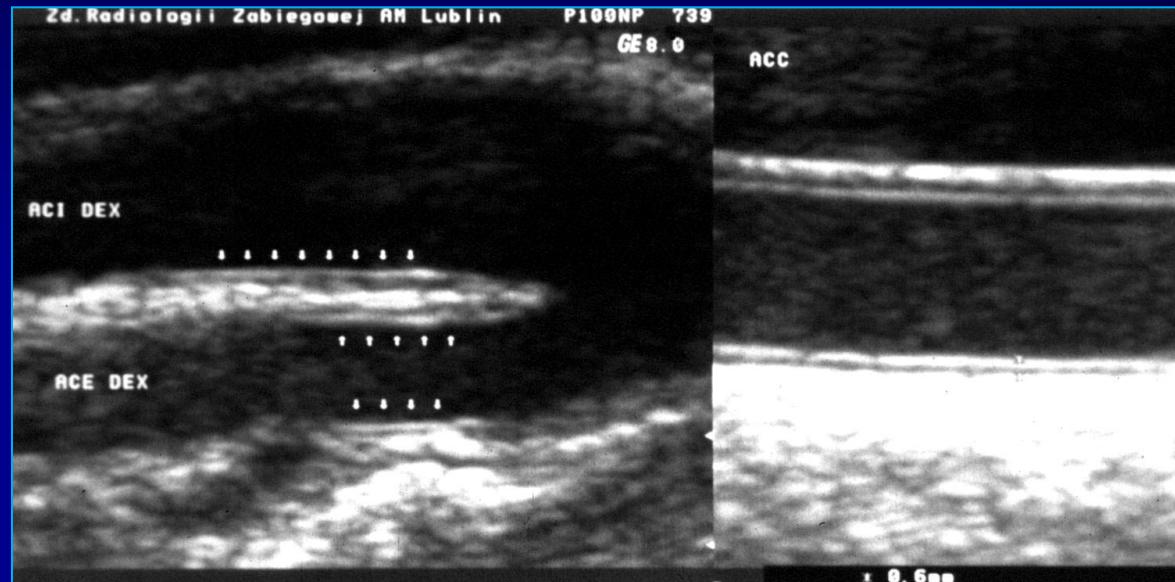
Vascular imaging



Vascular imaging - methodology

- Ultrasonography
 - standard B-mode
 - duplex Doppler
 - IVUS
- Arteriography
- Venography / phlebography
- Angio-CT
- Angio-MR
- Perfusion Imaging

Ultrasonography (standard B-mode)

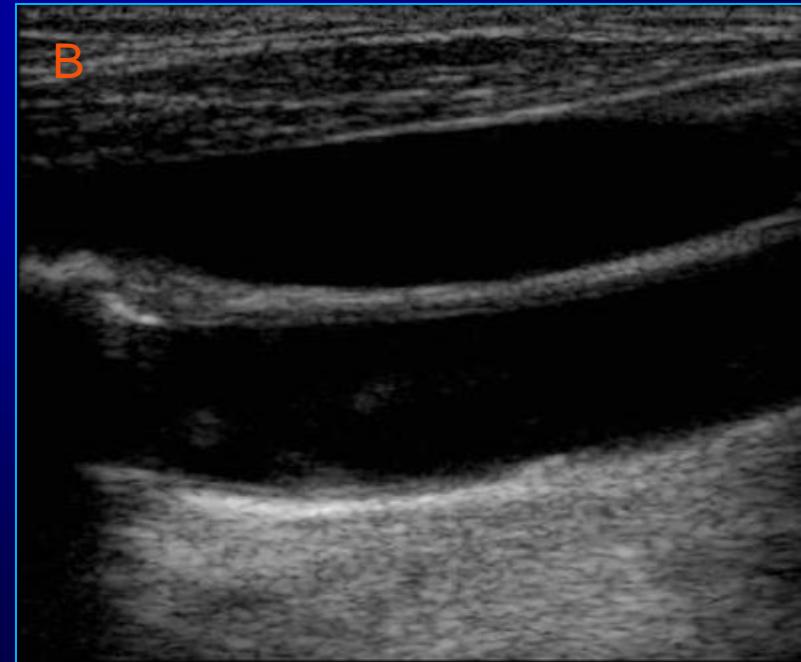
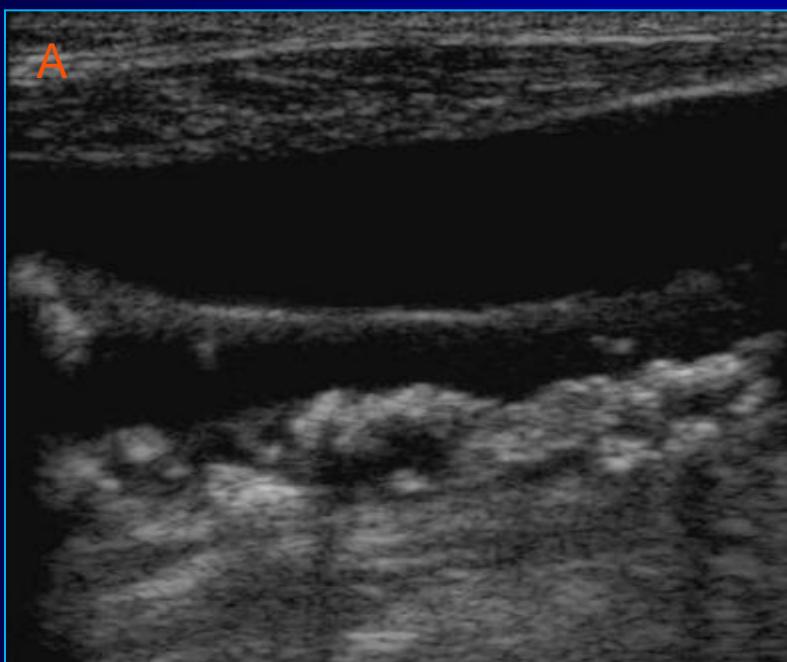
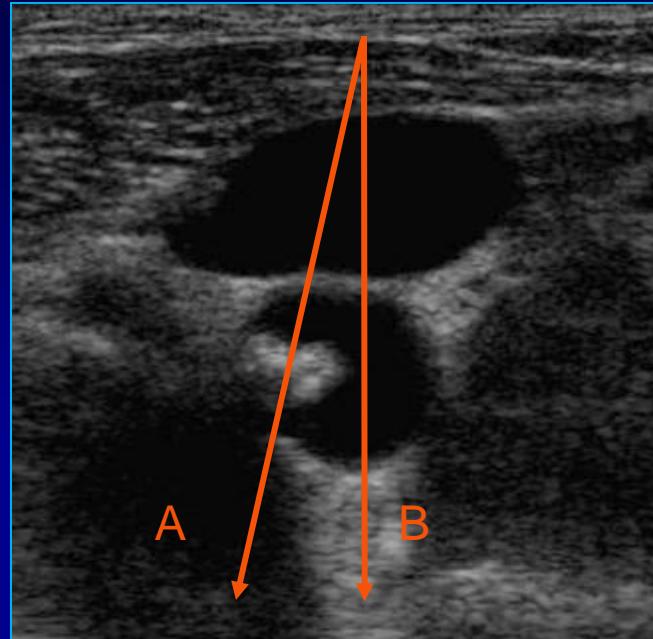


Ultrasonography

- non-invasive
- cost-effective
- available

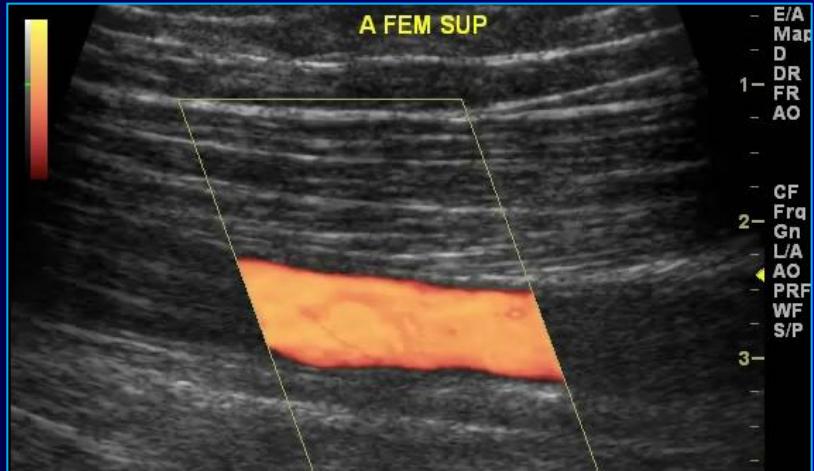
but

machine & operator
dependent

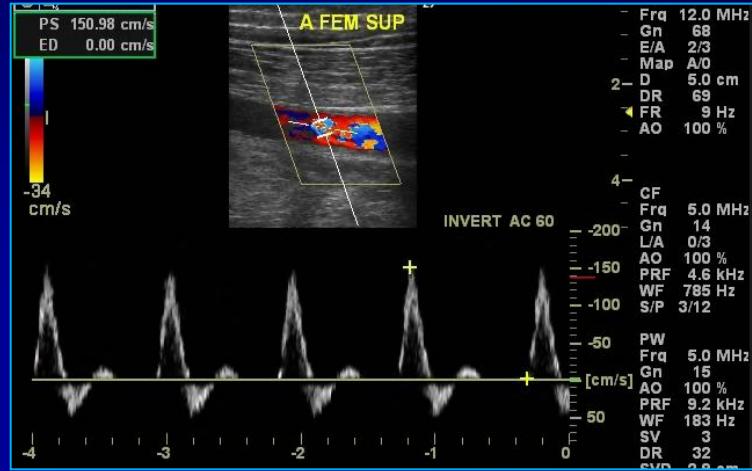


Duplex Doppler US

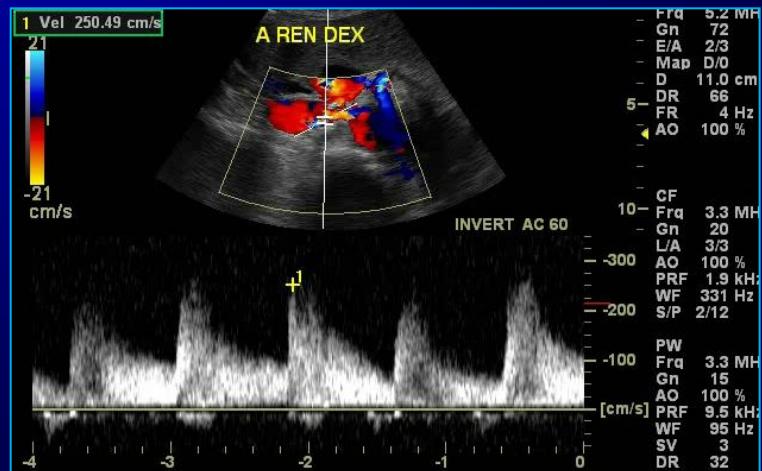
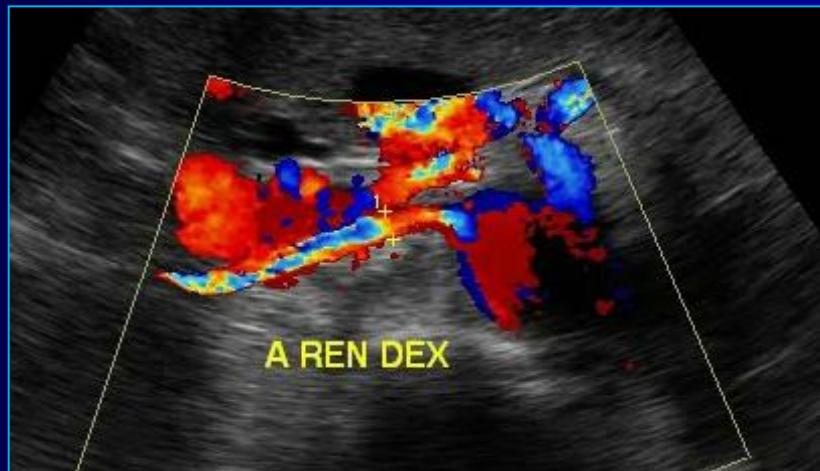
blood flow evaluation under B-mode control



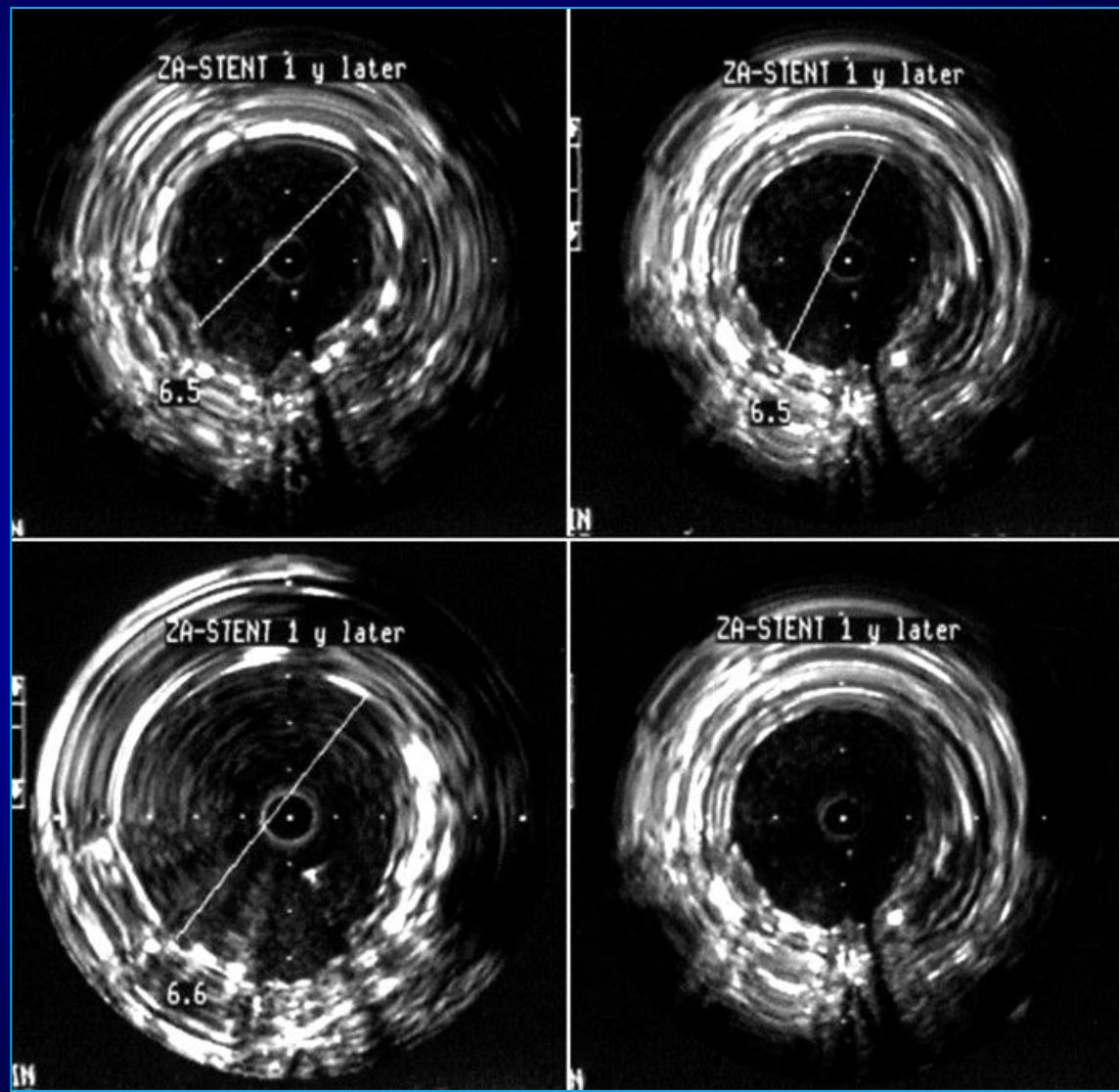
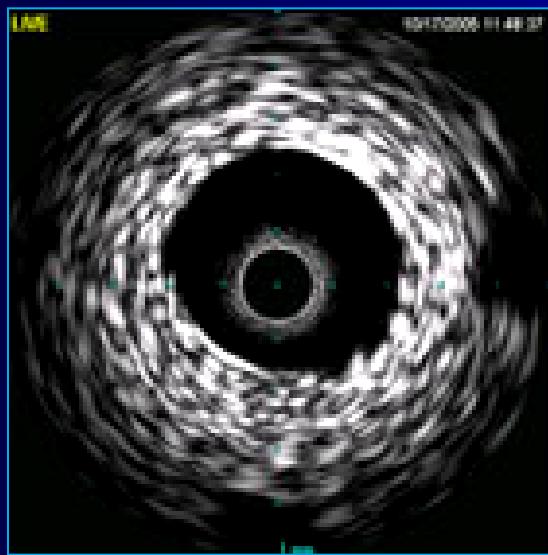
colour Doppler



spectral Doppler



IVUS IntraVascularUltraSound



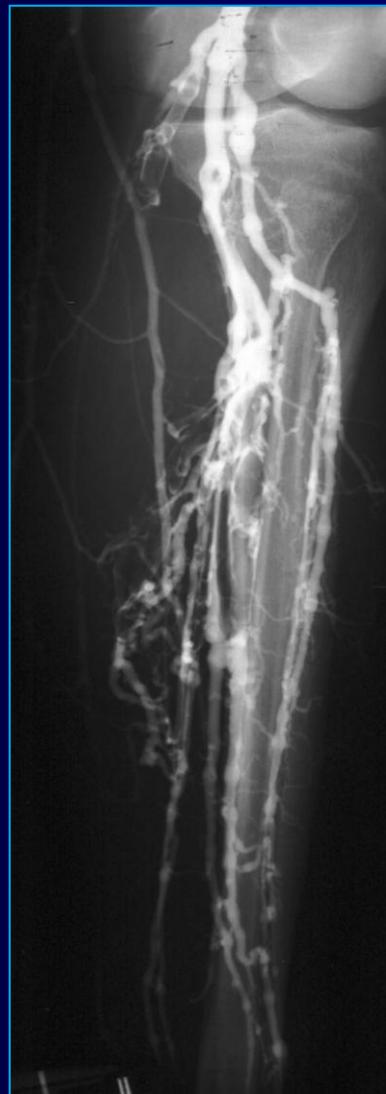
Arteriography



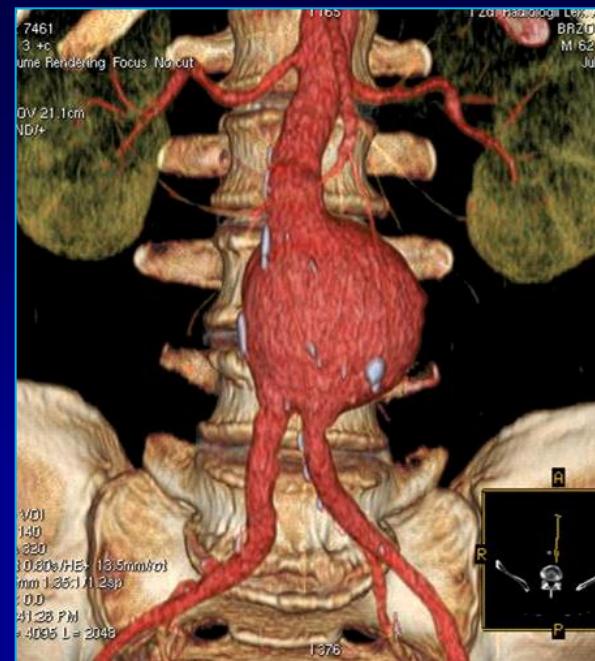
Angiocardiography / i.v. arteriography



Phlebography / venography



Angio - CT

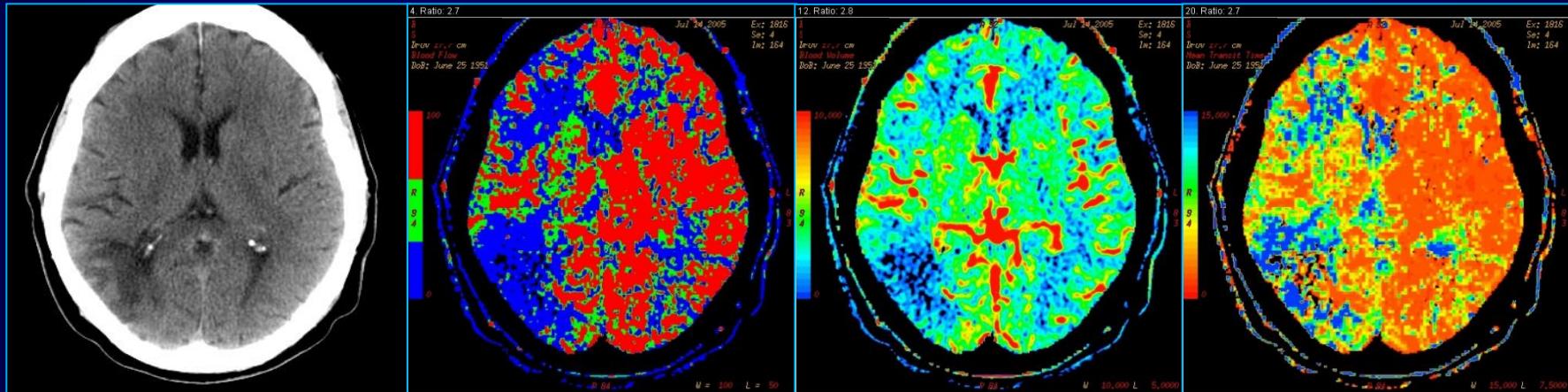


Angio - MR



Perfusion imaging

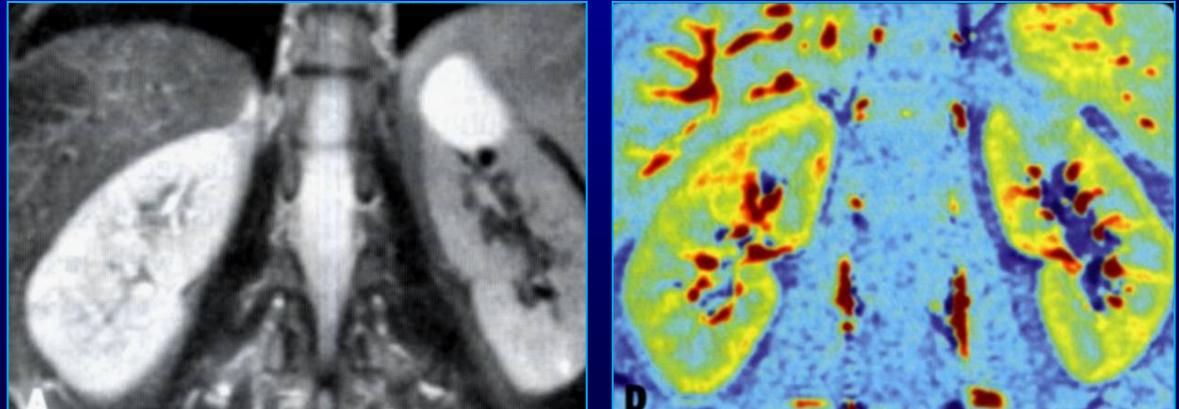
brain CT-perfusion



Perfusion parameters:

CBF (*cerebral blood flow*)
CBV (*cerebral blood volume*)
MTT (*mean transit time*)

kidney MR-perfusion



Vascular pathology

general

- Arterial diseases
- Venous diseases
- Vascular malformations / hemangiomas
- Hypervascularized neoplasms

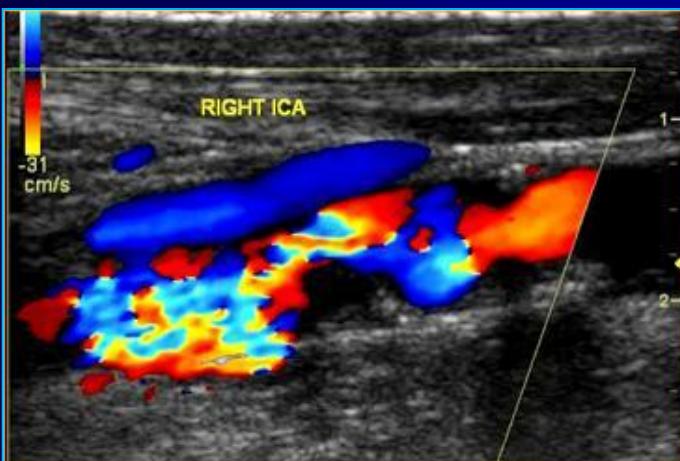
I. Arterial diseases

symptomatology – imaging features

- stenosis / occlusion
- arterial broadening
 - true aneurysm
 - false aneurysm (pseudoaneurysm)
- dissection / dissecting aneurysm
- a-v fistula
- „pathologic vessels“

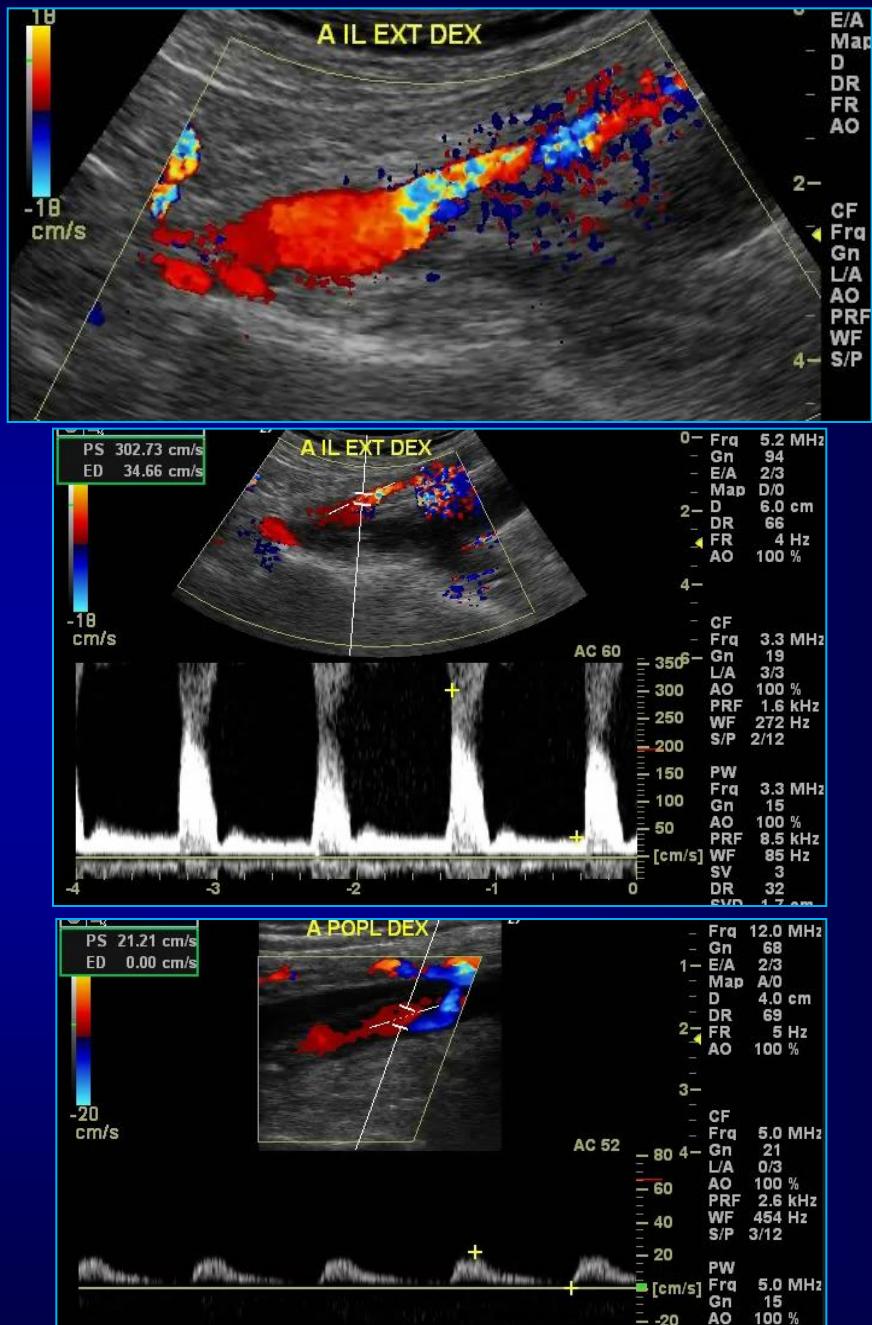
Internal carotid artery stenosis

Doppler US and arteriography



Stenosis

iliac arteries

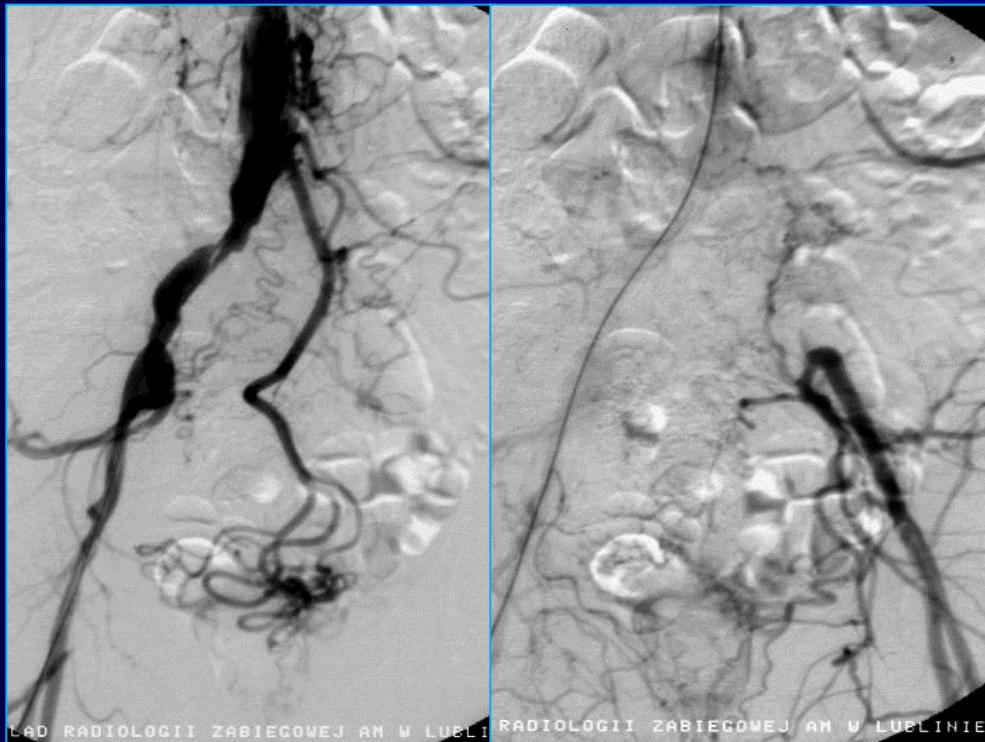


Aortic branches – stenosis

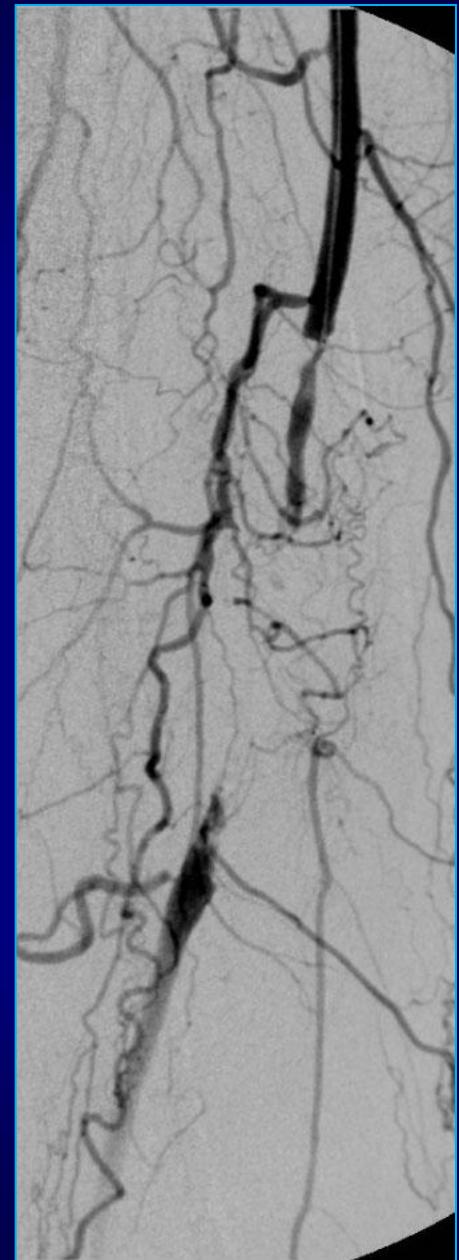


occlusion / collateral circulation

iliac arteries and SFA

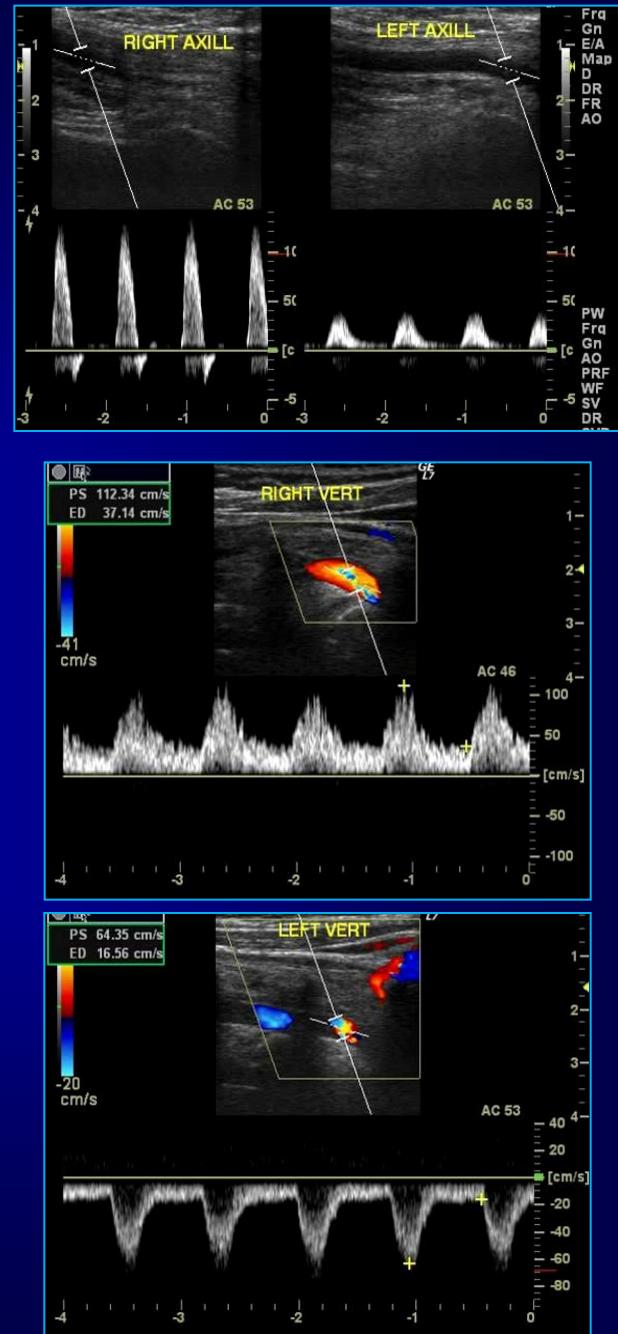


SFA occlusion collateral circulation



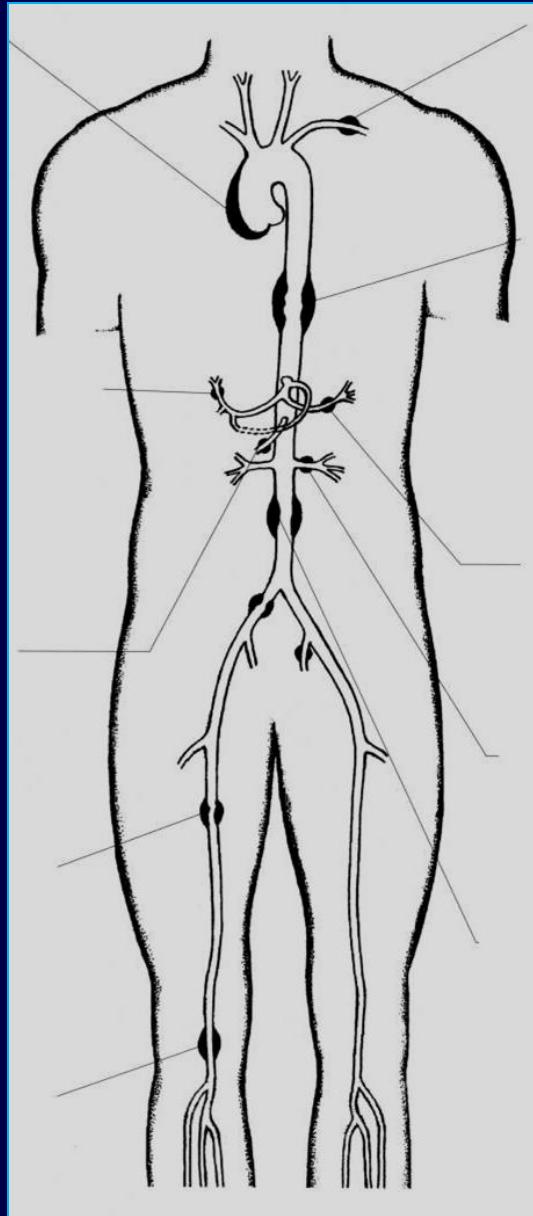
Left subclavian artery occlusion

subclavian steel syndrome



True aneurysms

location & morphology



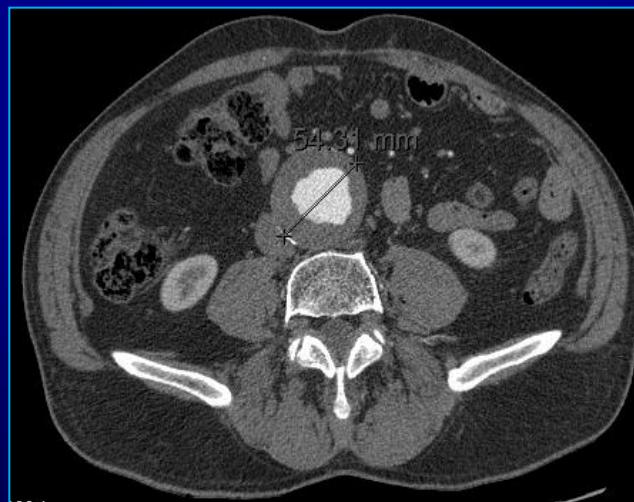
fusiform



saccular

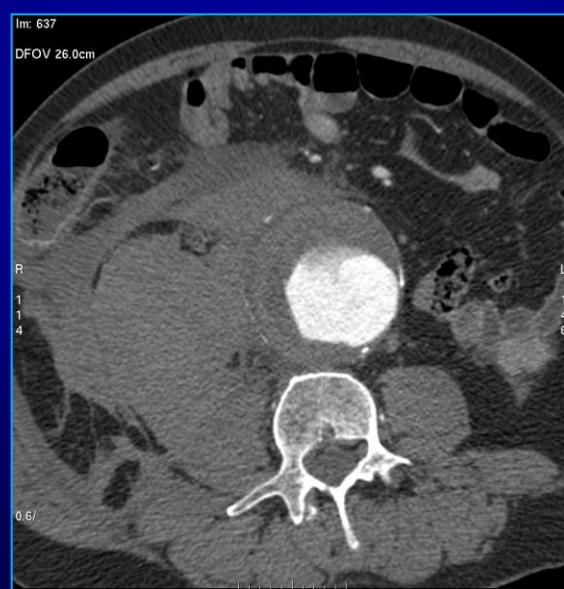
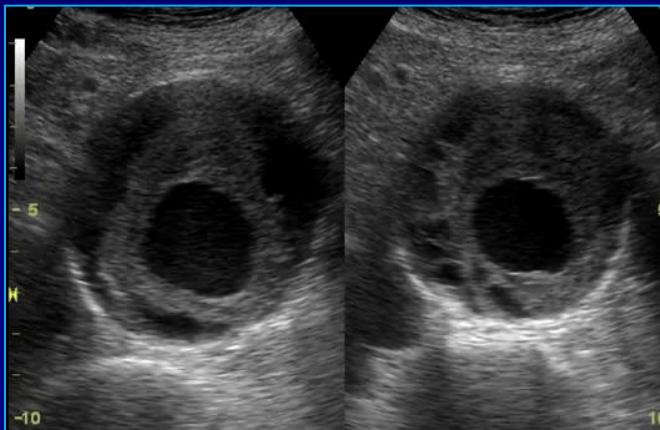
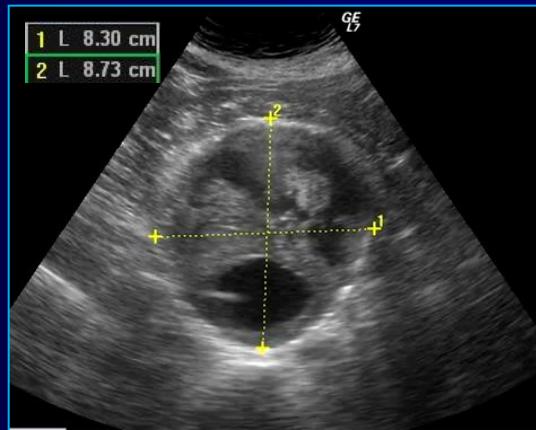
AAA abdominal aortic aneurysm

angiography (calibrated) / CT / CT-angio (2D and 3D)



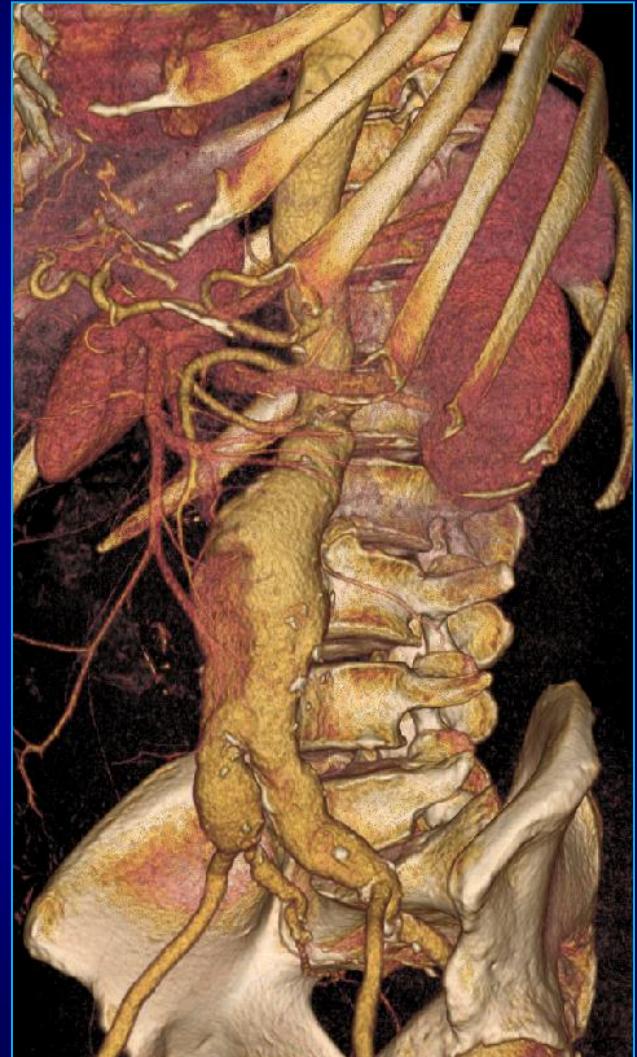
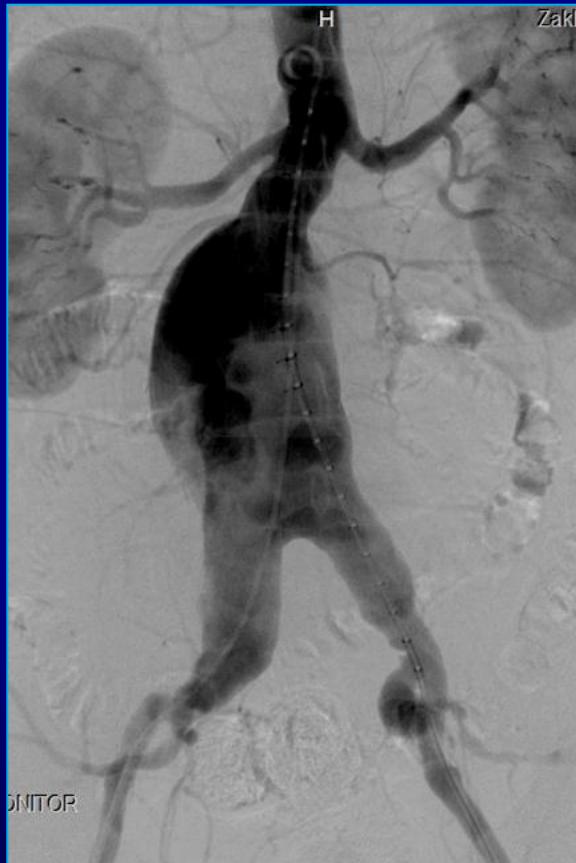
AAA aneurysm rupture US & CT

it is stated that AAA > 50 mm in diameter are more predisposed for rupture



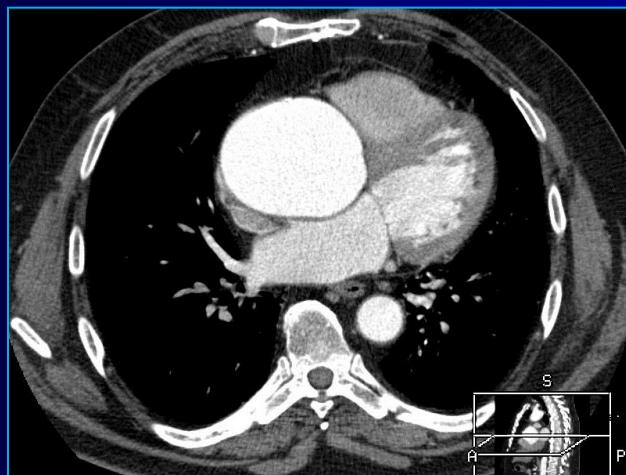
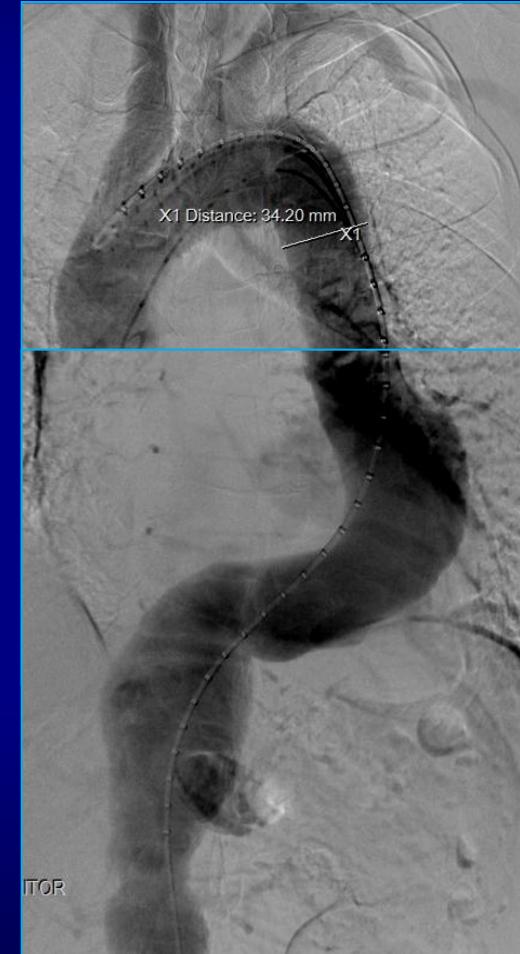
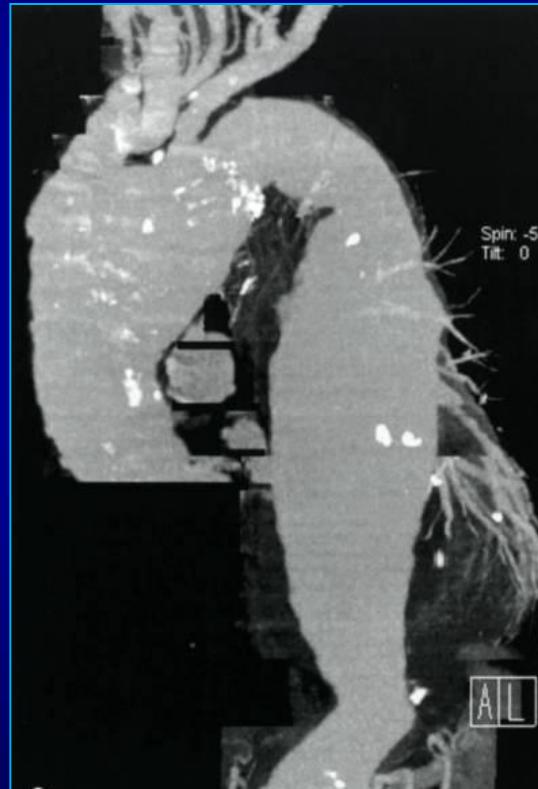
aorto-iliac aneurysms

angiography / angio-CT



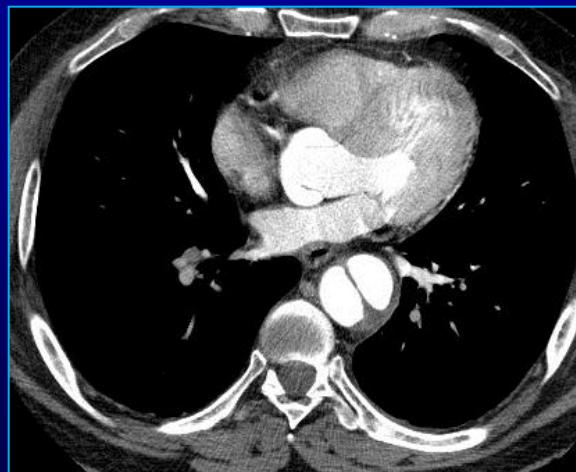
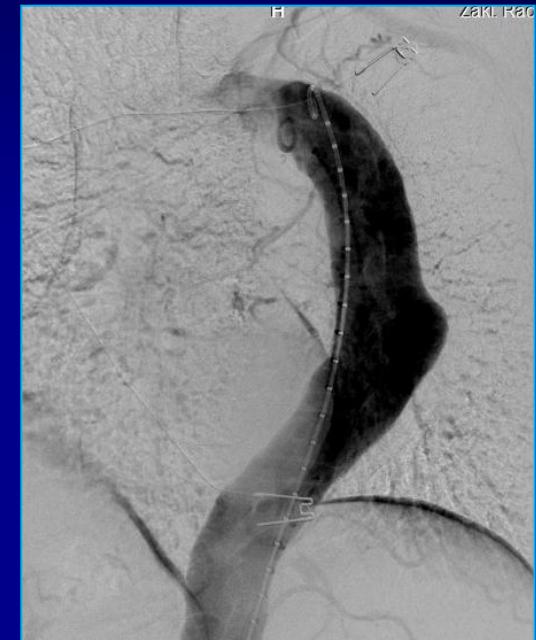
TAA - aneurysm of ascending / descending aorta

angiography / CT / Angio-CT



Aortic arch / descendong aortic aneurysm

angiography / CT



renal & visceral aneurysms

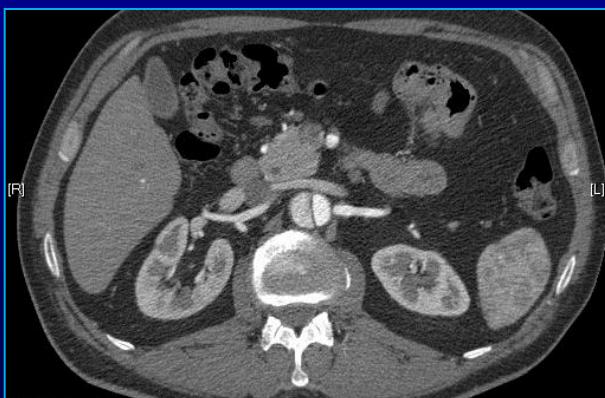


Post-traumatic false aneurysm

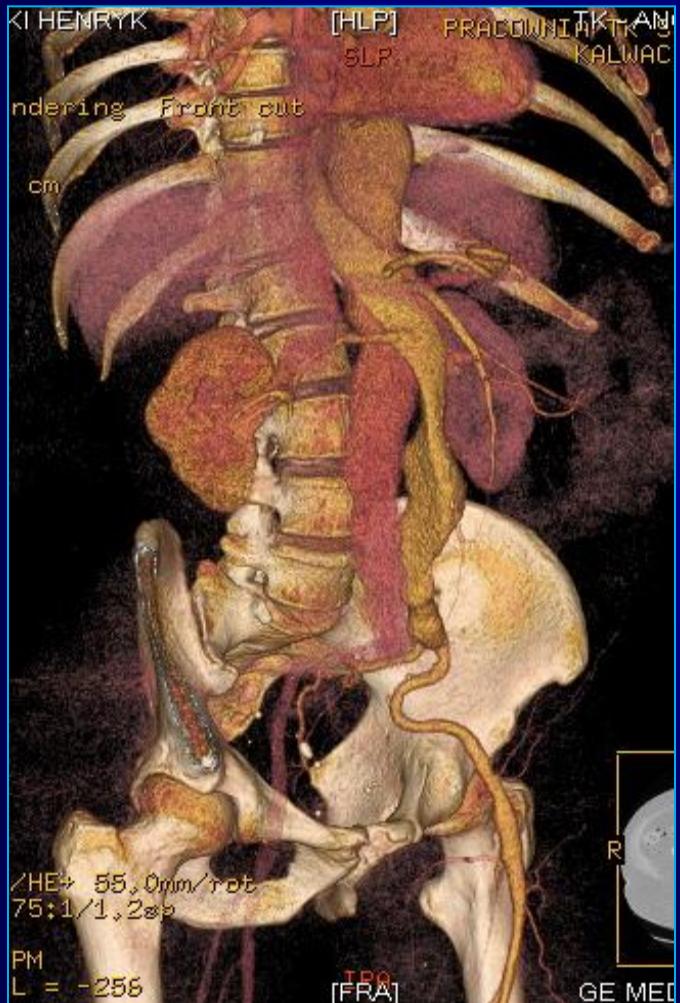
peripheral pseudo-aneurysms



Aortic dissection

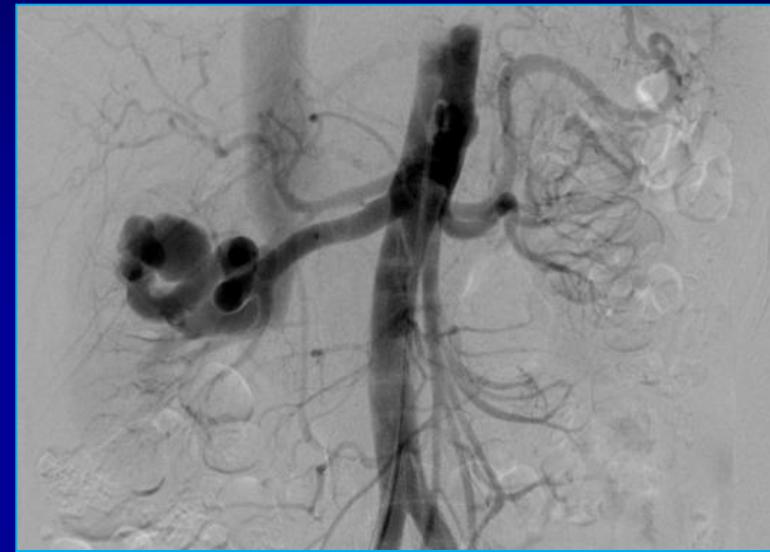
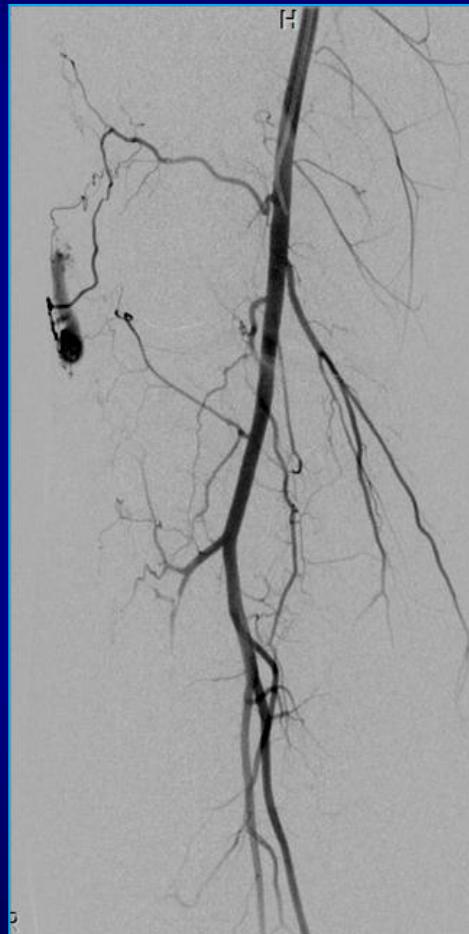
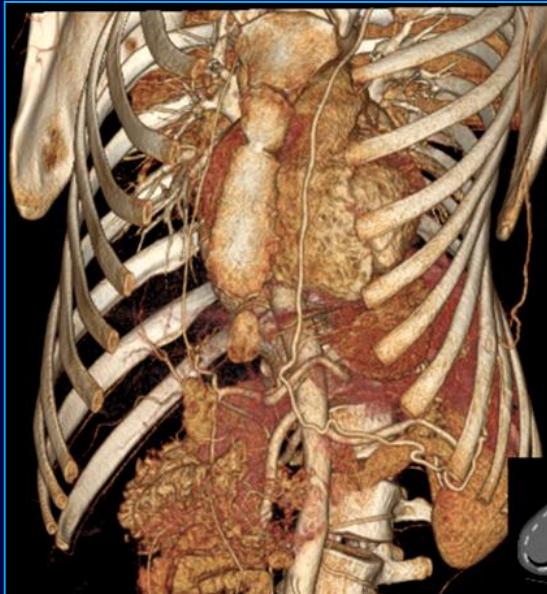


Dissecting aortic aneurysm

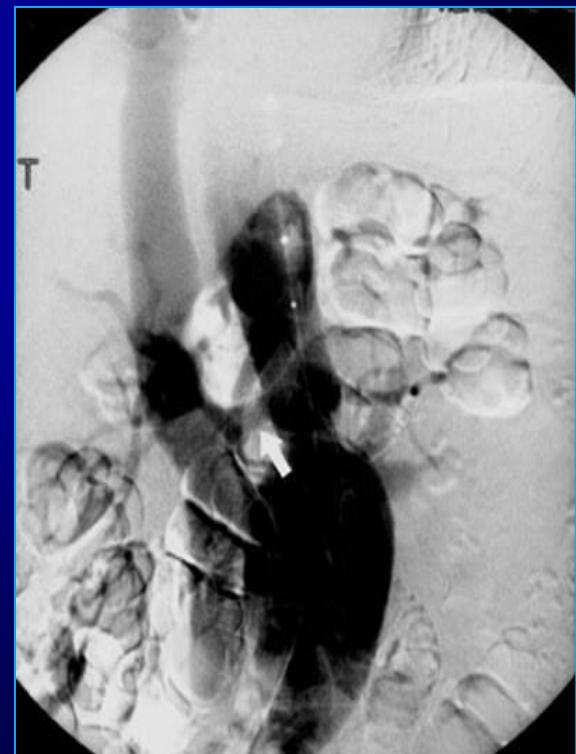
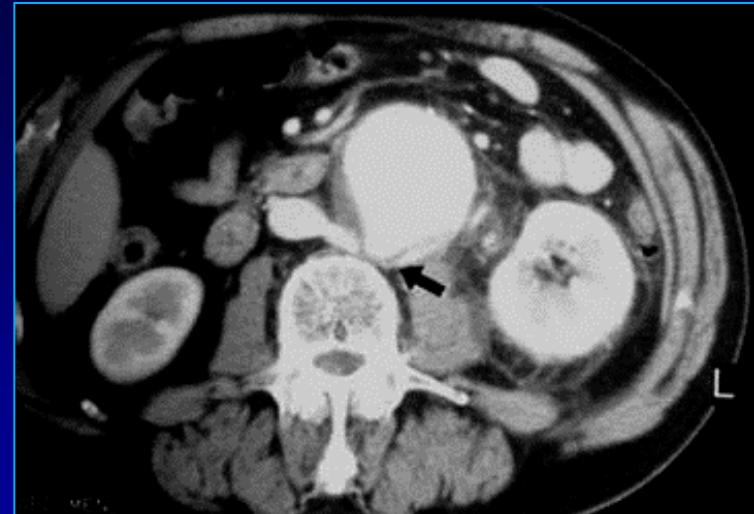


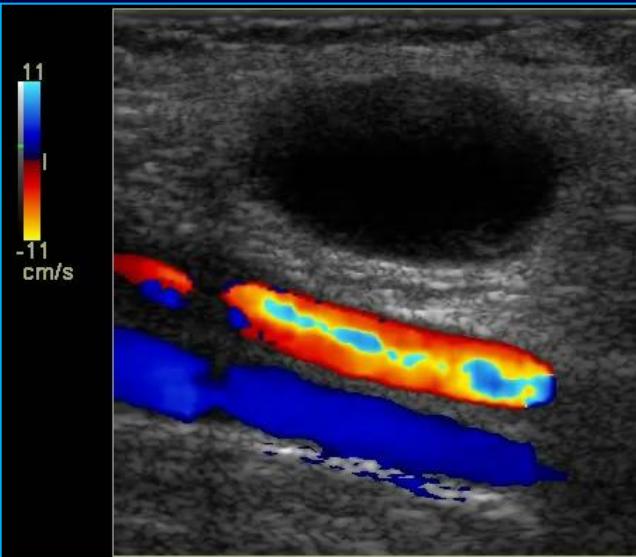
Arterio-venous fistulas

spontaneous / congenital / post-traumatic



AAA complicated with aorto-caval fistula





Iatrogenic arterial injuries

after femoral artery puncture



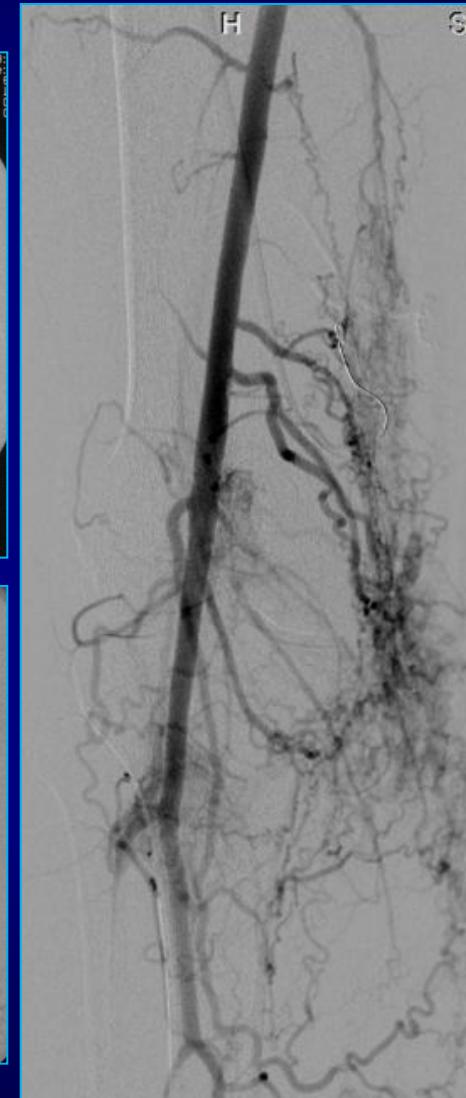
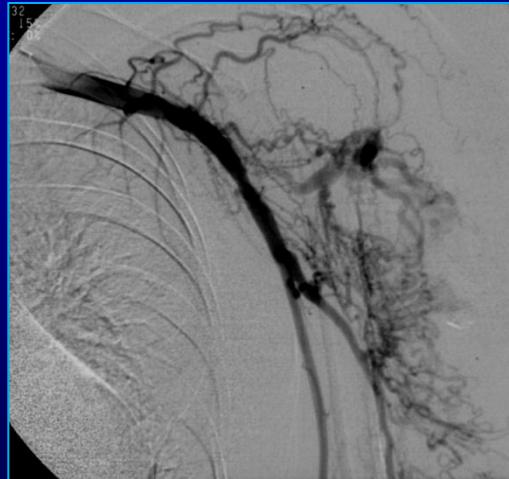
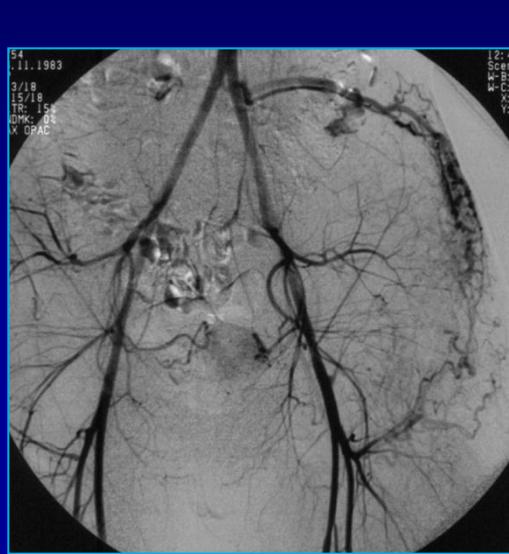
hematoma / pseudoaneurysm / a-v fistula





Pathologic vessels

neoplasms / vascular malformations



Arterial diseases - ethiology

1. Atherosclerosis !!!
2. vasculitis
3. fibro-muscular dysplasia (FMD)
4. Reynaud's fenomenon
5. arterial embolism
6. compression syndromes
7. angiopathies in systemic disorders
8. genetic angiopathies
9. arterial injuries

1. Atherosclerosis

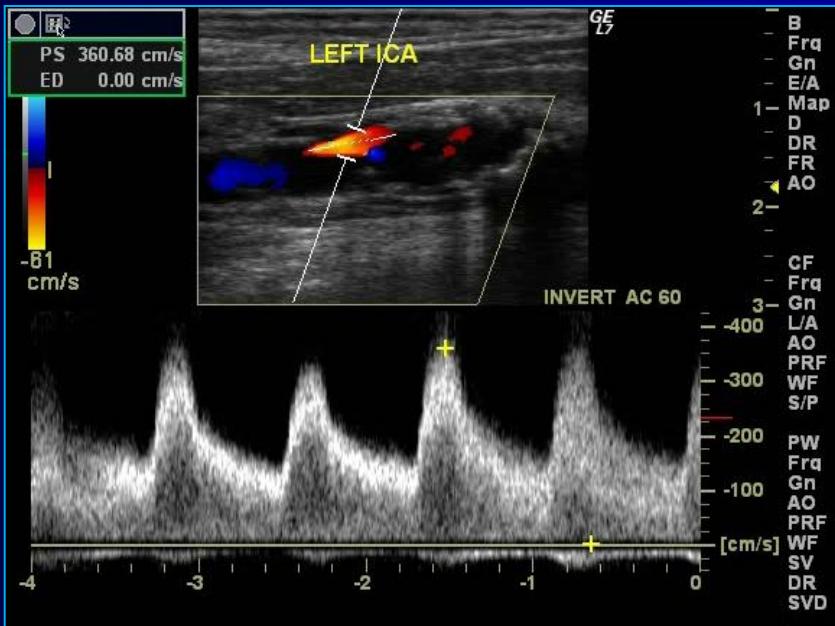
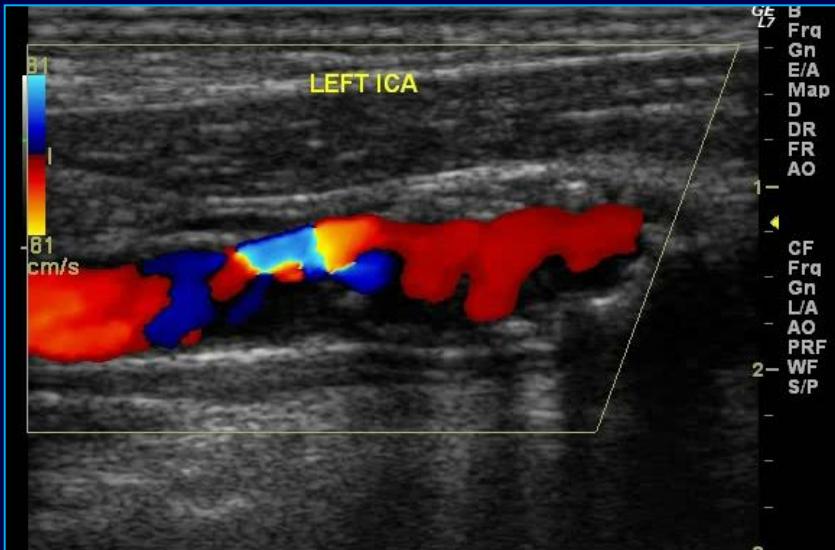
atheromatosis

it affects arteries:

- extracranial → TIA, stroke
- coronary → angina pectoris / cardiac infarcts
- lower limbs → intermittent claudication

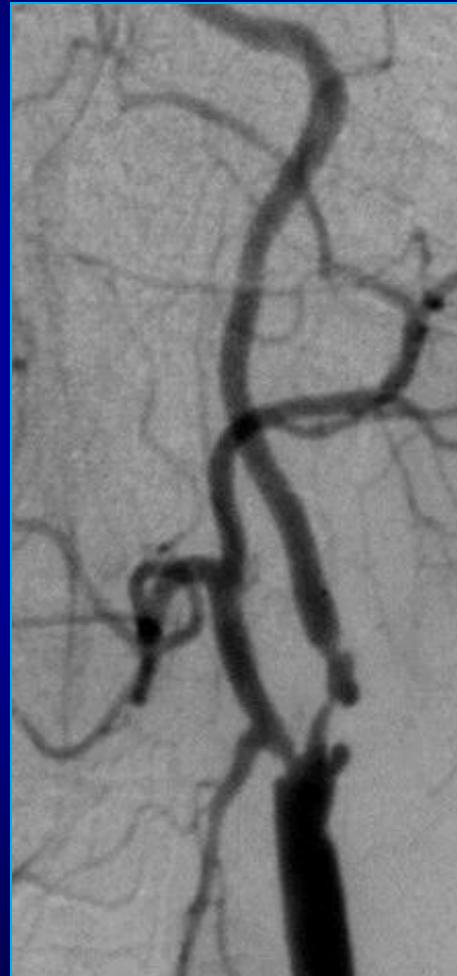
atherosclerosis risk factors:

- arterial hypertension
- smoking
- dyslipidemia/ diabetes/ obesity
- male gender / age > 60



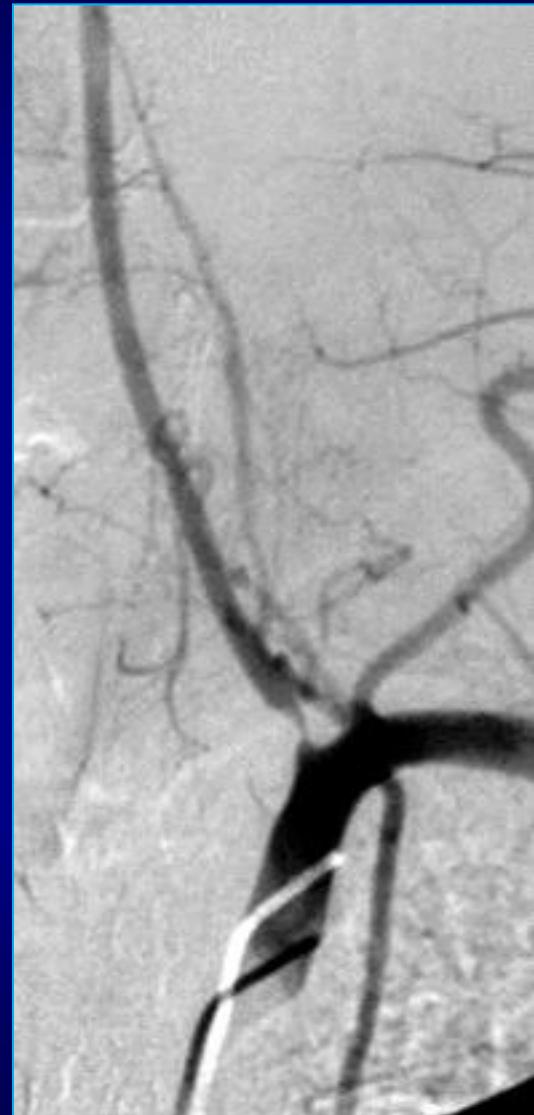
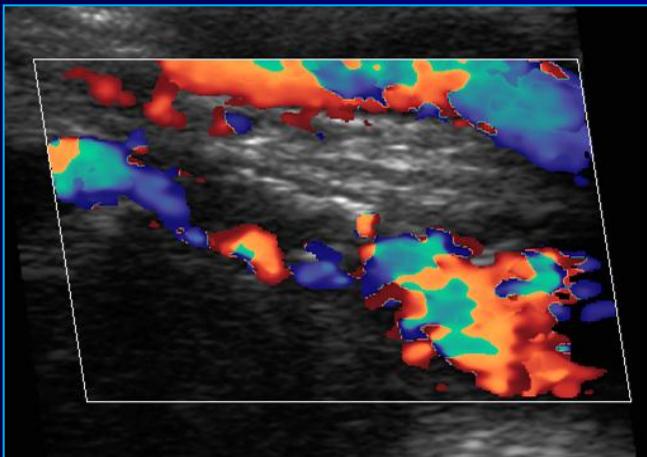
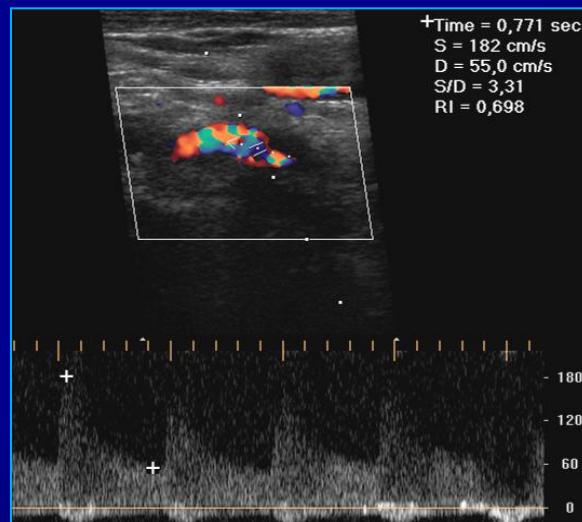
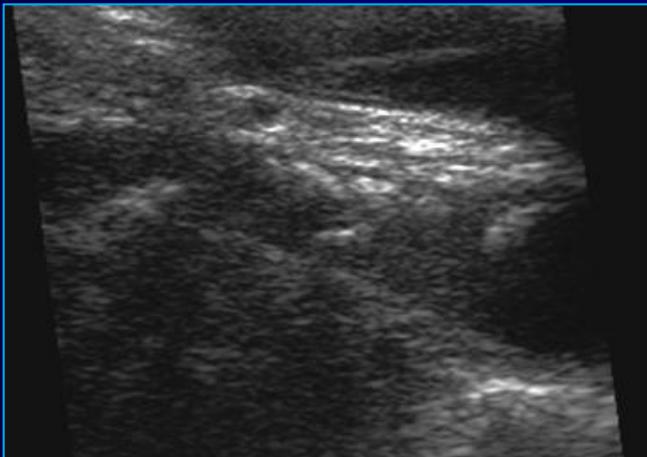
Arteriosclerotic ICA stenosis

Doppler US / angiography



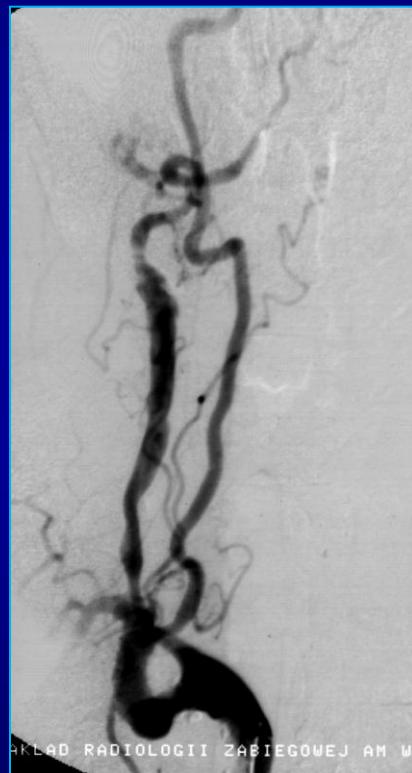
Vertebral artery stenosis

Doppler US and angiography



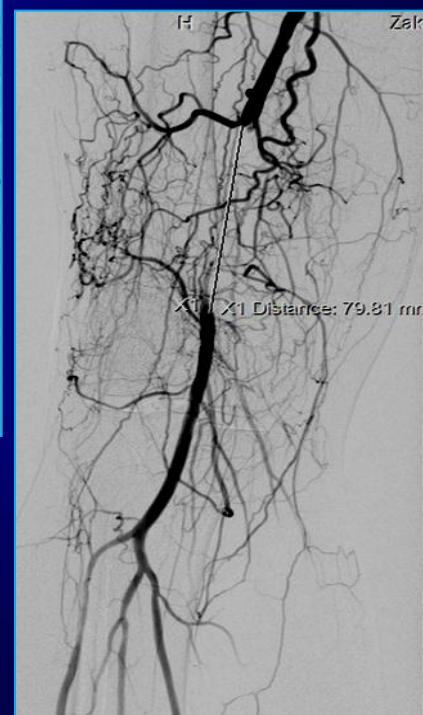
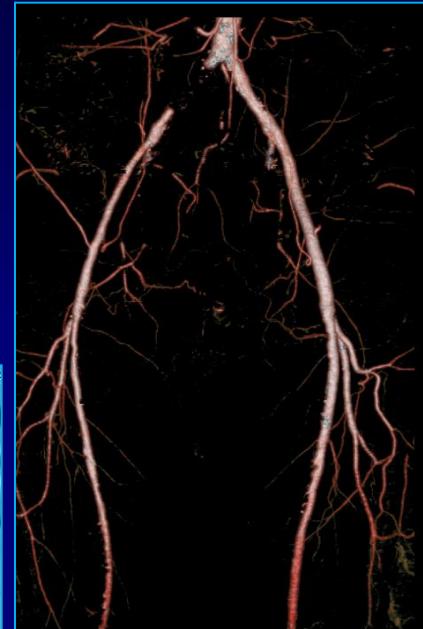
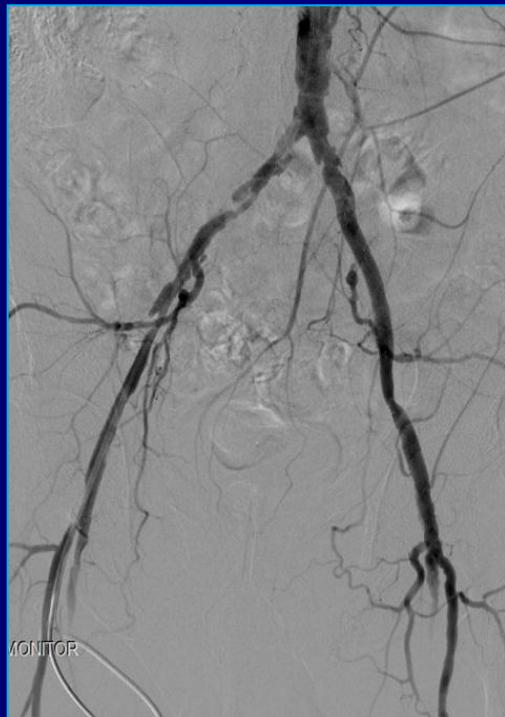
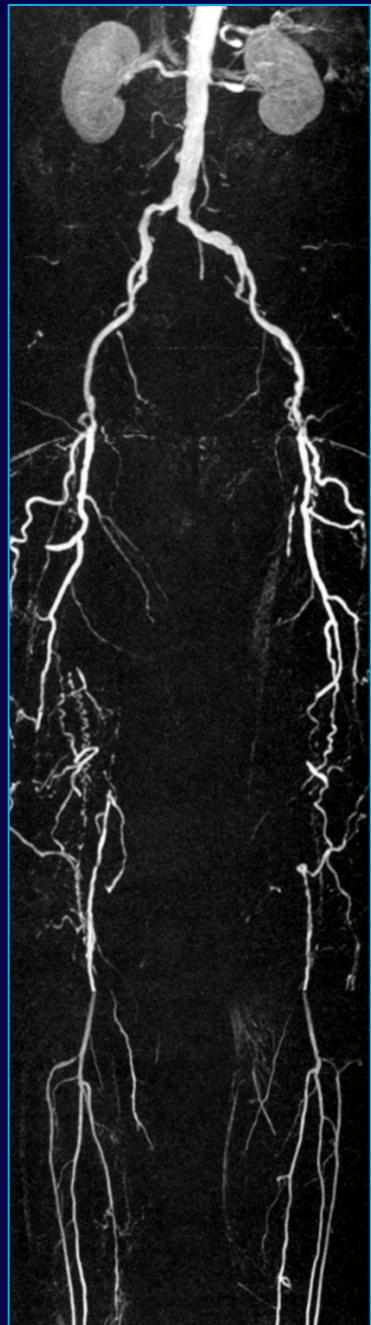
Advanced arteriosclerosis

of aortic arch & extracranial antebrain arteries



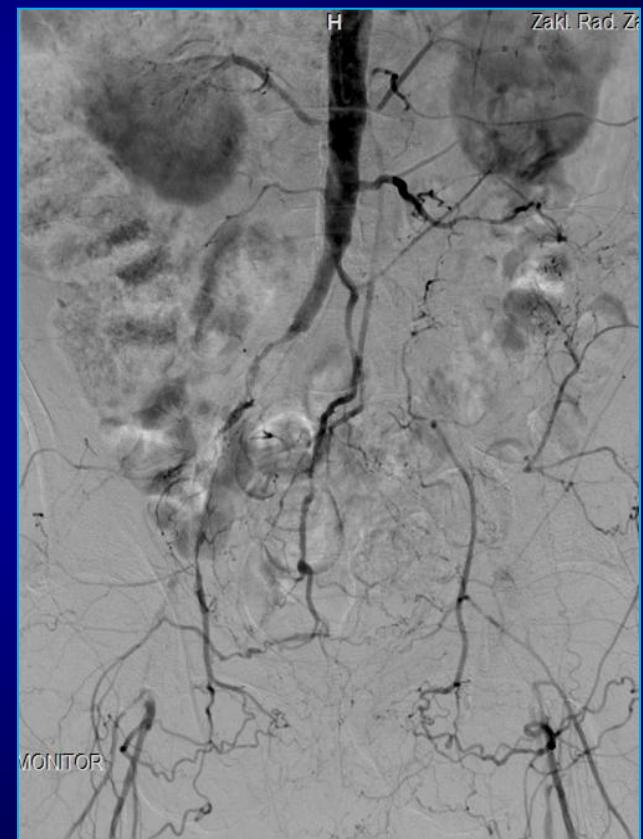
Atherosclerosis of lower limb arteries

femoral & iliac obstruction – most frequent



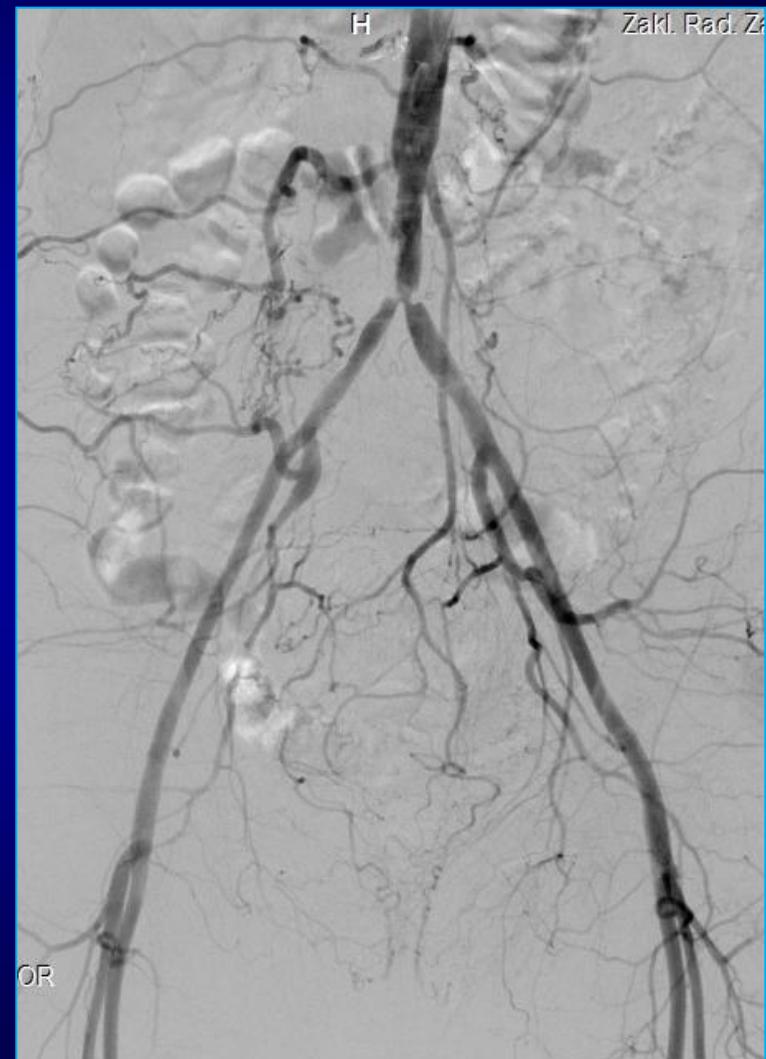
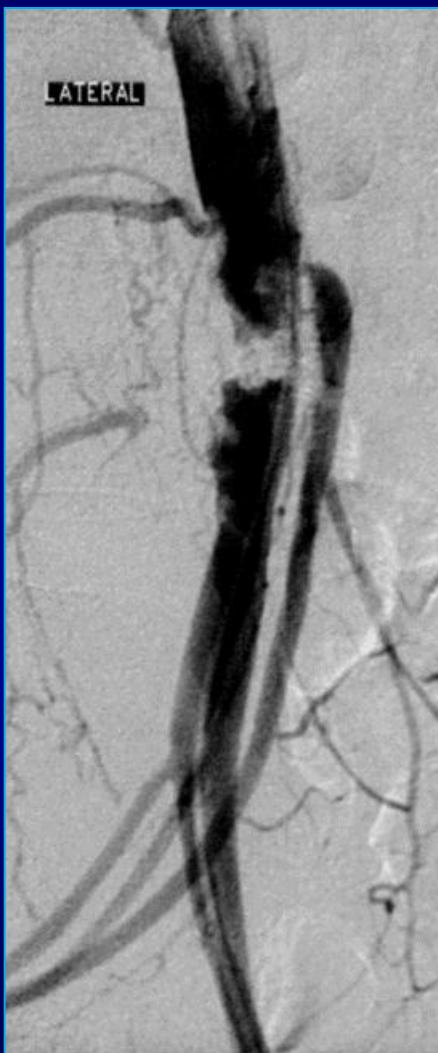
Atherosclerosis of lower limb arteries

extensive wall calcifications



Leriche syndrome

no palpable pulse in groins



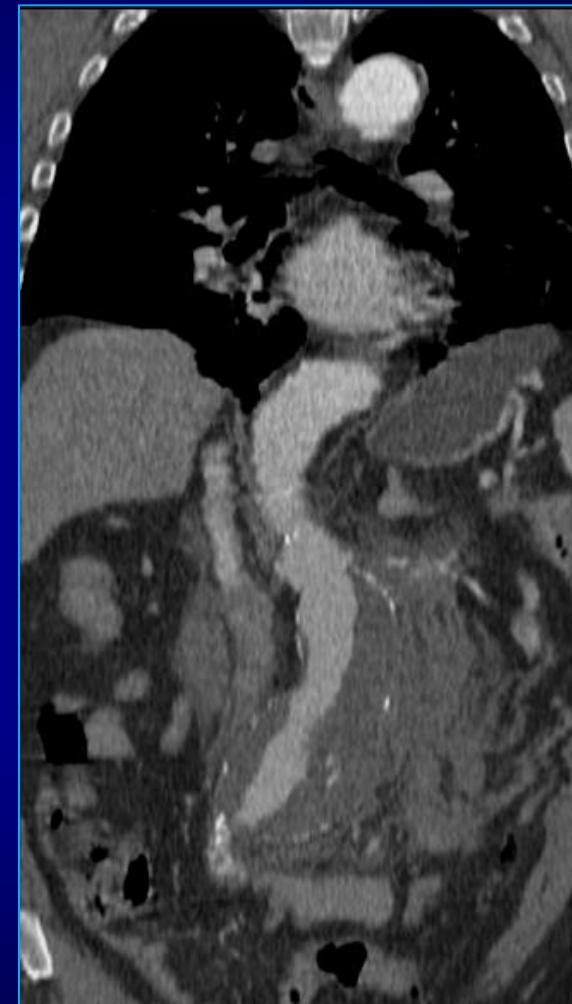
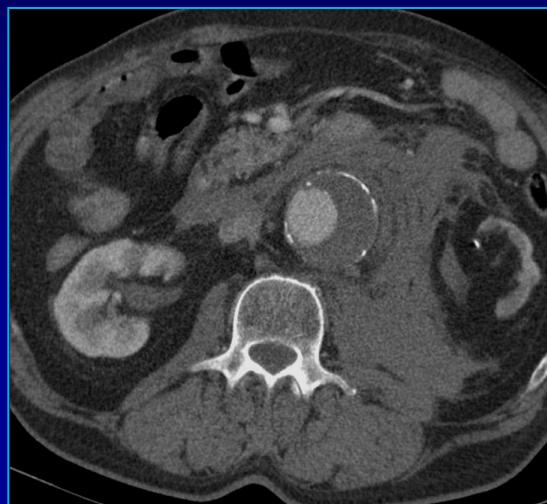
Atherosclerosis aorto-iliac aneurysms



How atherosclerosis may change abdominal aorta & iliacs ?



AAA ruptured



atherosclerotic true aneurysms

other locations:
popliteal / internal iliac



2. Inflammatory vascular diseases

(*angiitis, arteritis, vasculitis, aortitis*)

heterogenic group of pathology with not clear ethiology

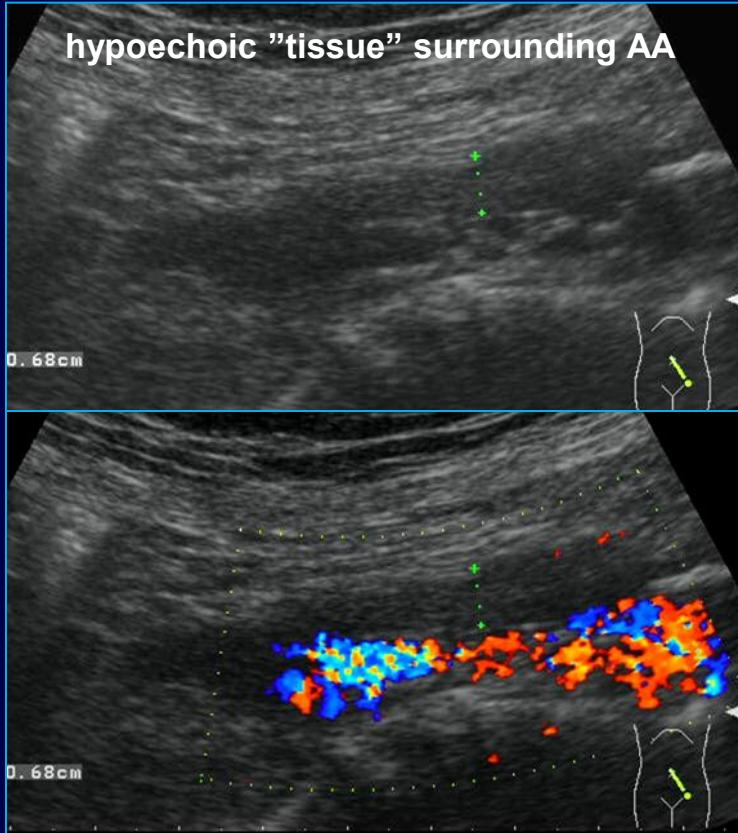
Typical features?

- young patients (mainly women)
- no atherosclerosis
- smooth stenosis followed by local broadening

Special cases of *vasculitis*:

- Takayasu disease ("no pulse disease")
- giant-cell arteritis - *temporal arteritis*
- *polyarteritis nodosa*
- Bürger's disease (*thromboangiitis obliterans*)

hypoechoic "tissue" surrounding AA



after pharmacotherapy



Aortitis

non-specific / mycotic / historically - luetic

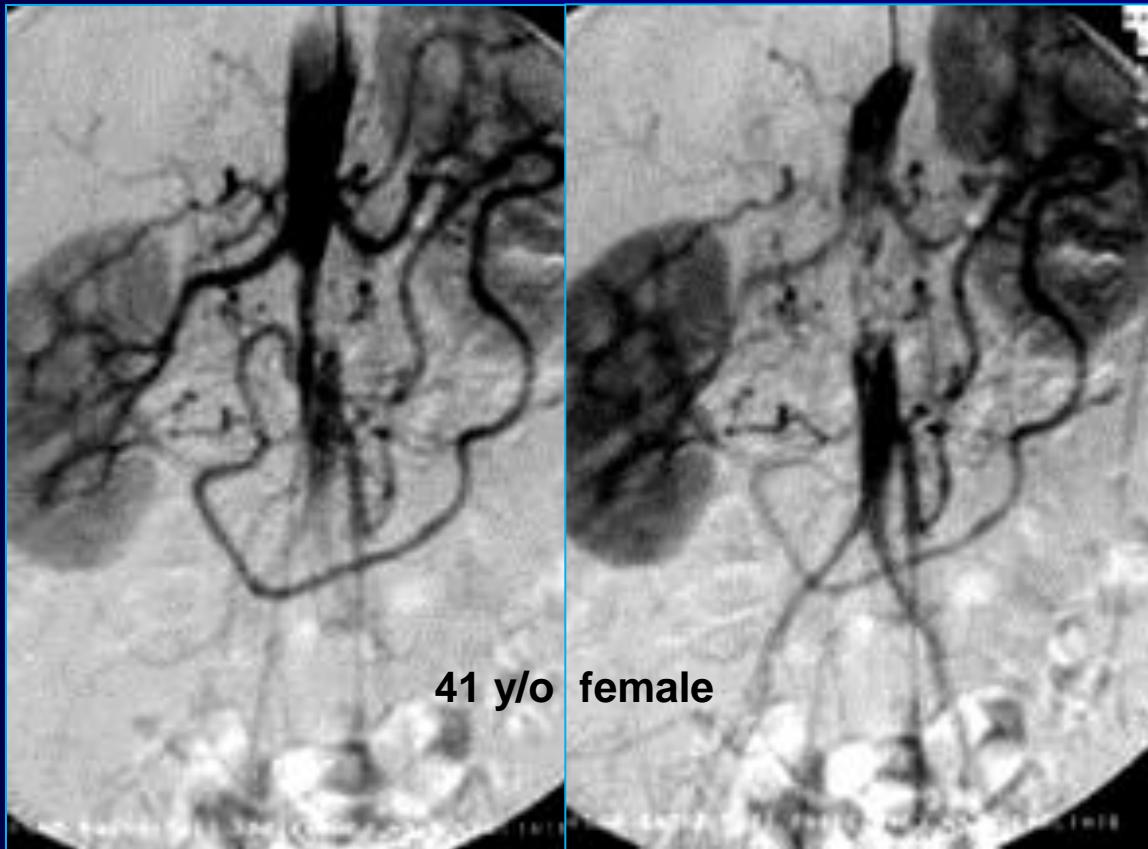


abdominal pain, fever, leucocytosis
& intermittent claudication



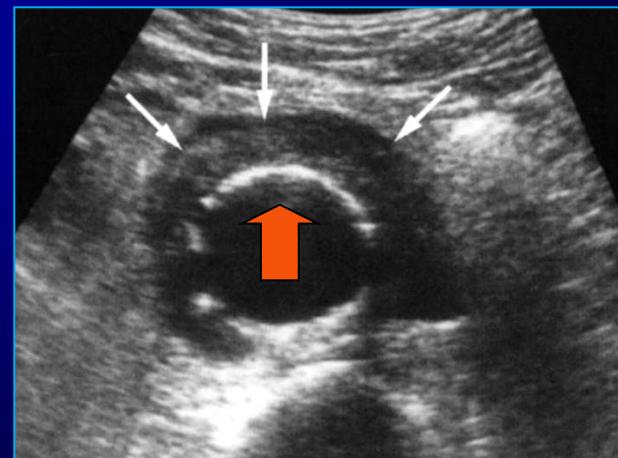
occlusion / stenosis of abdominal aorta

pain, fever, leucocytosis ➔ aortitis suspected !!!



Inflammatory AAA

periaortic infiltration – contrast enhancement in CT

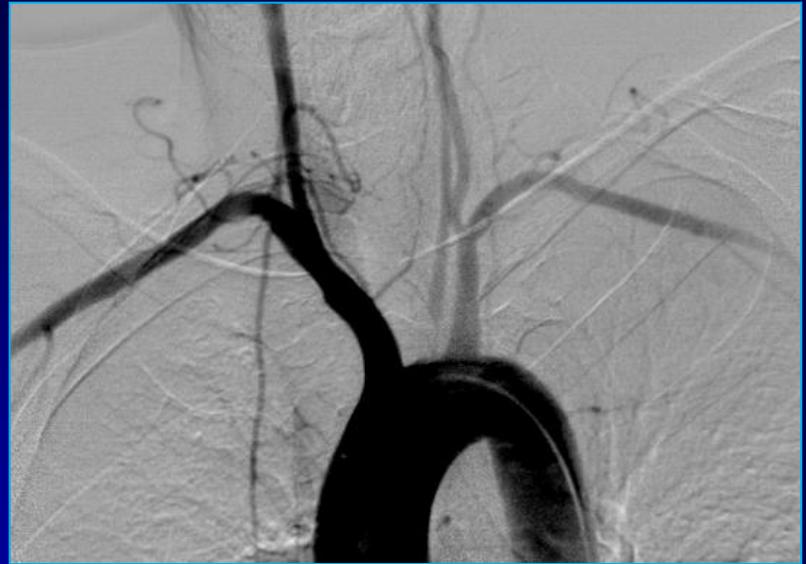


Takayasu disease

80% in young females



smooth stenoses / occlusions
of aortic arch arteries





27 y.o. male

isolated
renal artery stenosis

- *vasculitis* ?
- FMD ?

14 y.o. girl

stenosis of abdominal aorta
& both renal arteries

- coartation ?
- *vasculitis, aortitis* ?
- abdominal Takayasu ?



Polyarteritis nodosa

periarteritis nodosa

- kidneys (80%)
- heart muscle (70%)
- brain (60%)
- liver / bowel (40%)

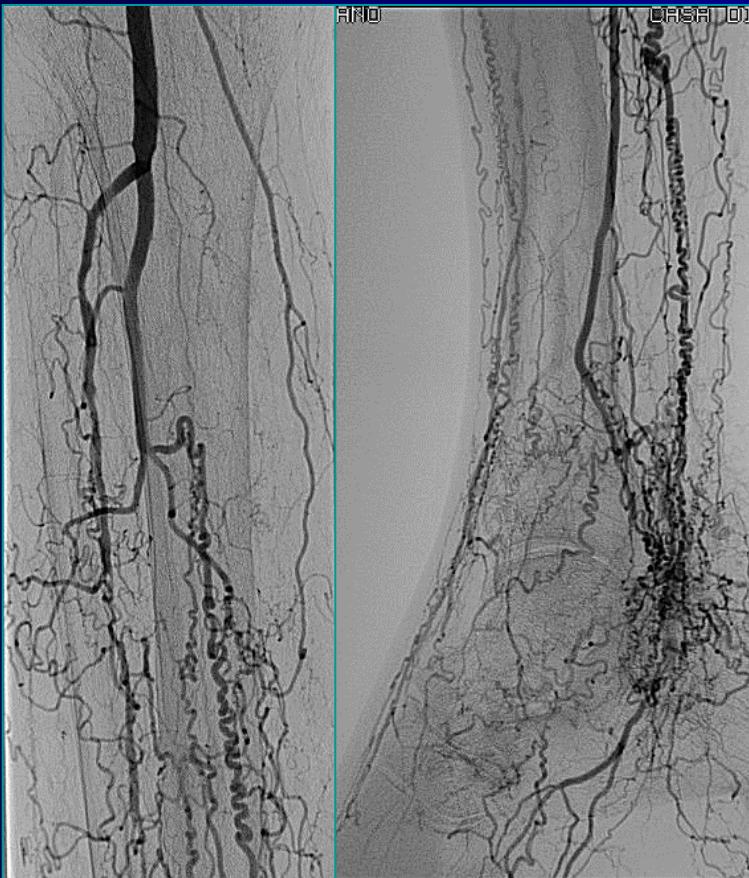


Bürger's disease

TAO – *thromboangiitis obliterans*



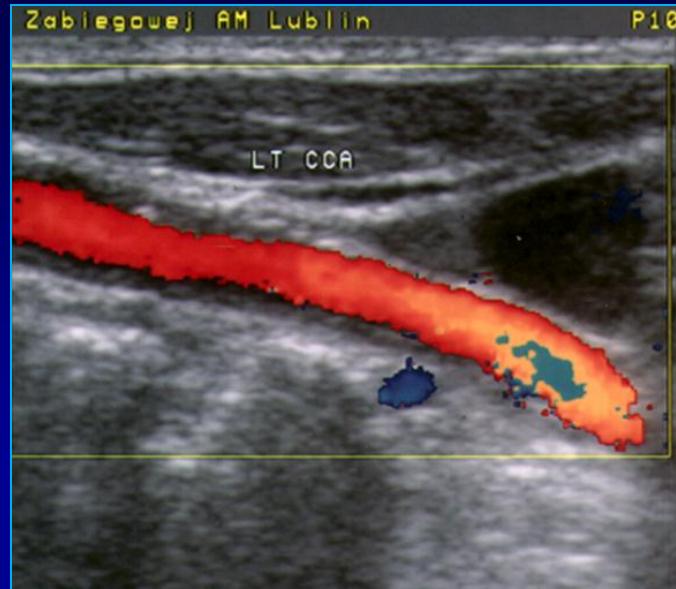
disease of young male smokers !!!



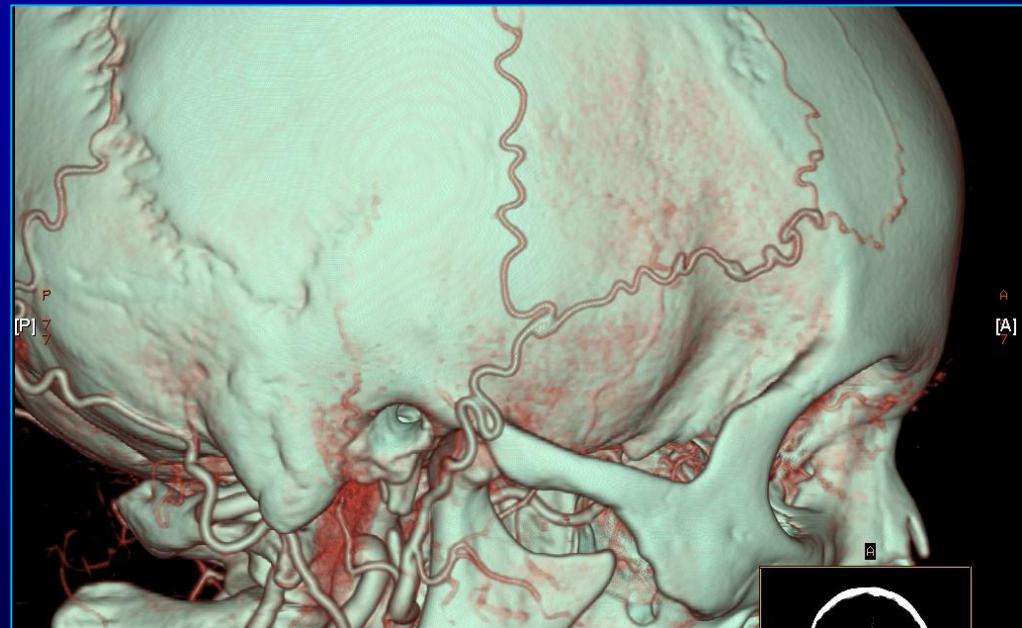
Zaklad Neuroradiologii u Lublinie

Zaklad Neuroradiologii u Lublinie

Arteritis *post-radiation*



giant-cell arteritis *temporal arteritis*

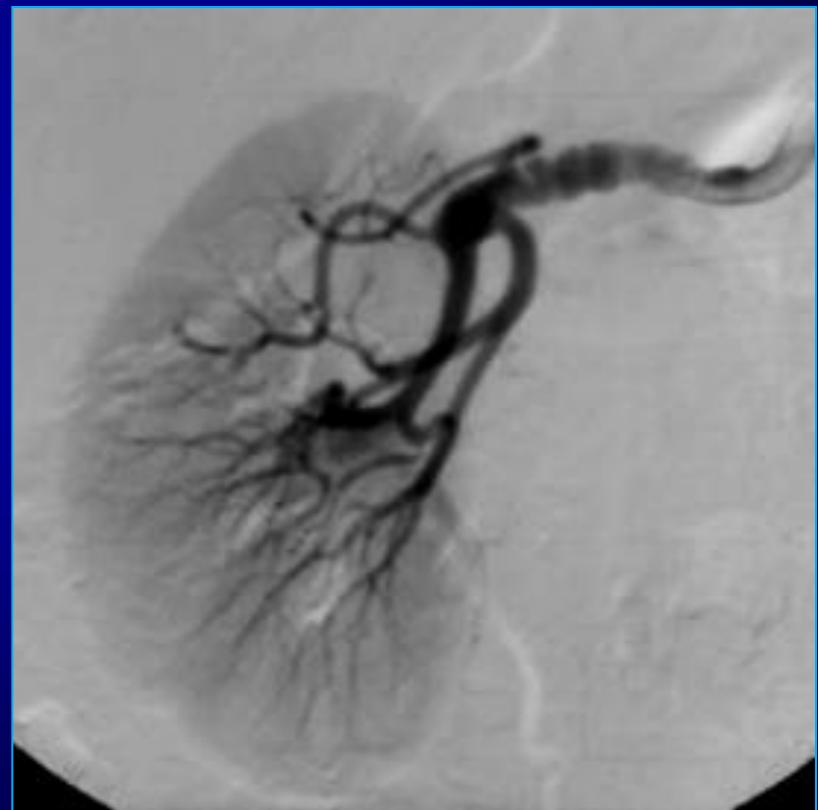


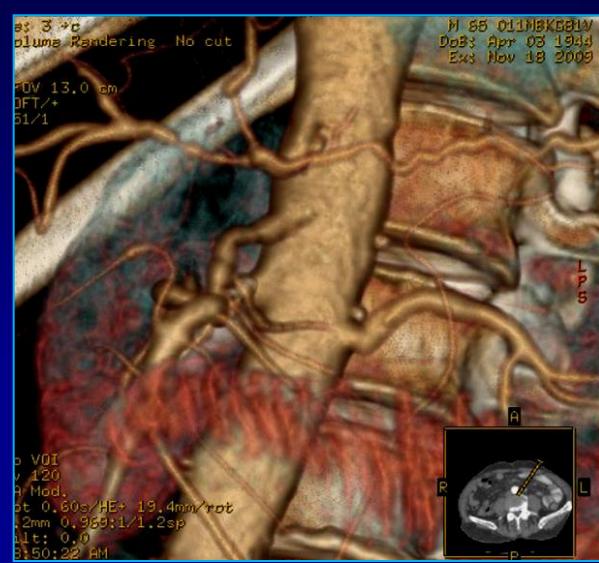
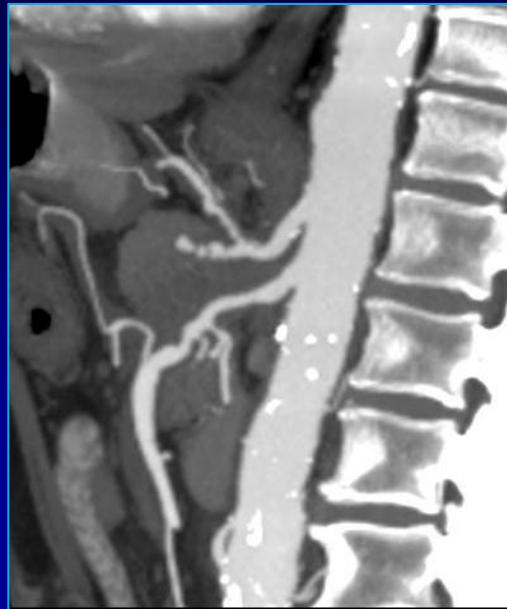
3. Fibromuscular dysplasia (FMD)

- ethiology not established
- histopathology:
 - atrophy & fibrosis of middle muscular layer
- mainly in renal arteries
 - very seldom in carotids & visceral arteries
- characteristic images
 - "string of pearls" - stenosis / broadening / stenosis
 - isolated smooth stenosis (seldom)
- young women disease



typical FMD images
"string of pearls" sign

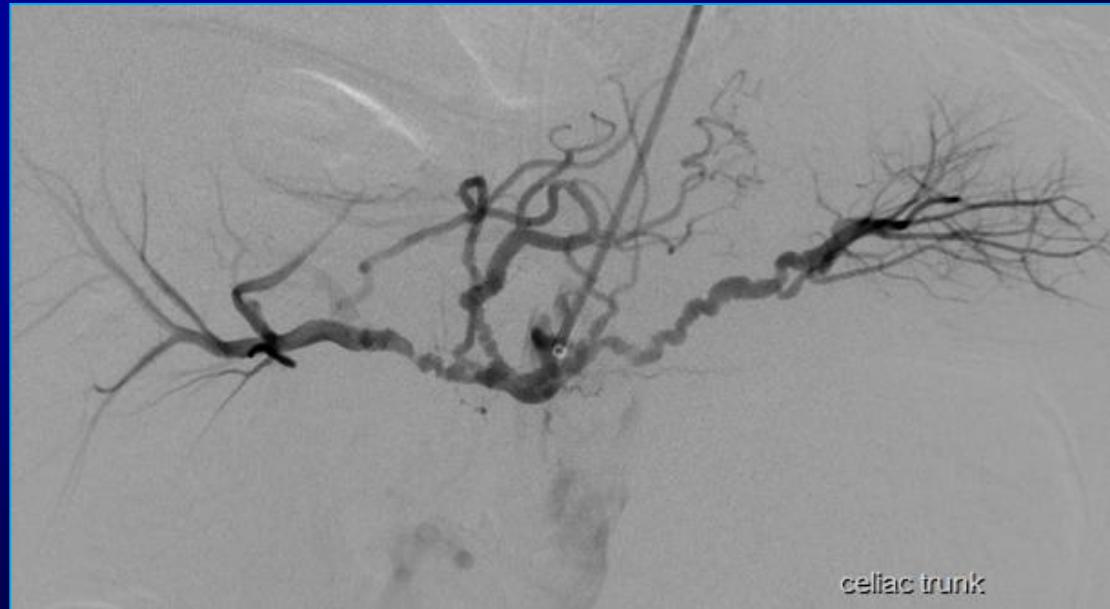




55 y.o. man

"string of pearls" sign ?

FMD? vasculitis?



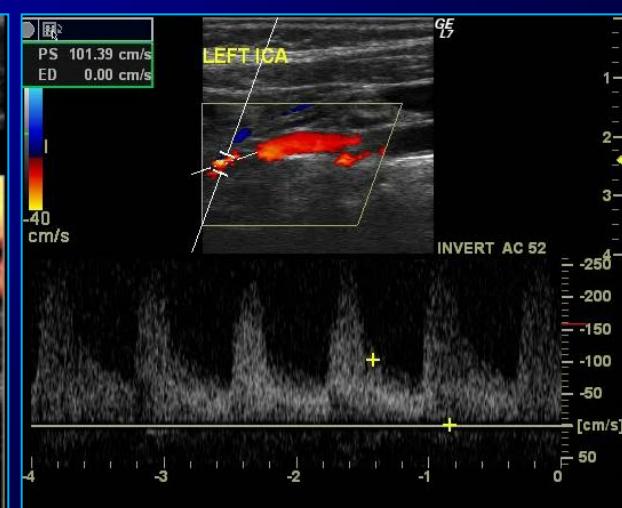
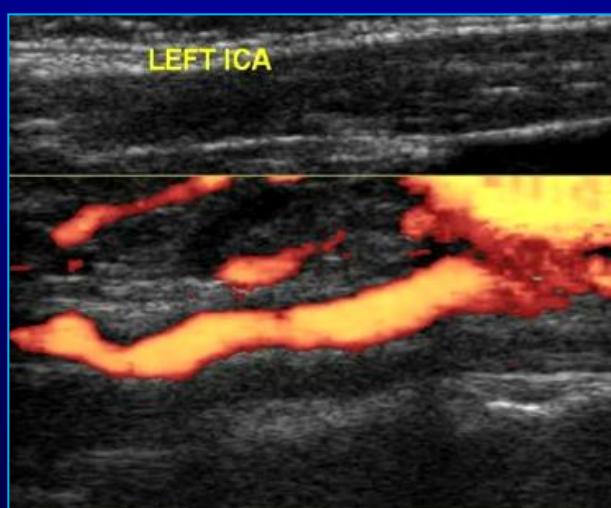
21 y.o. male with isolated ICA stenosis

- no atherosclerosis
- possible FMD



possible FMD or non-specific arteritis

41 y.o. female with long, segmental ICA stenosis (no atherosclerosis)





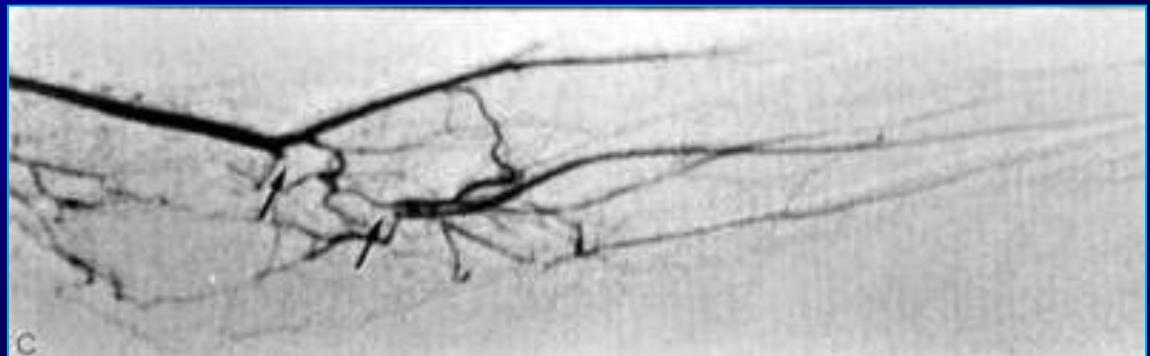
4. Reynaud fenomenon

sudden palmar arteries spasm



finger's ischemia

- Reynaud's disease
spontaneous
- Reynaud's syndrome
symptom of other diseases



5. Arterial embolism

most of arterial emboli come from the heart !!!



cardiac arrhythmia (atrial fibrillation)
release thrombi from the heart

- | | |
|-----------------------|--------------------|
| ▪ cerebral embolism | → ischemic stroke |
| ▪ mesenteric embolism | → abdominal angina |
| ▪ lower limb embolism | → foot ischemia |

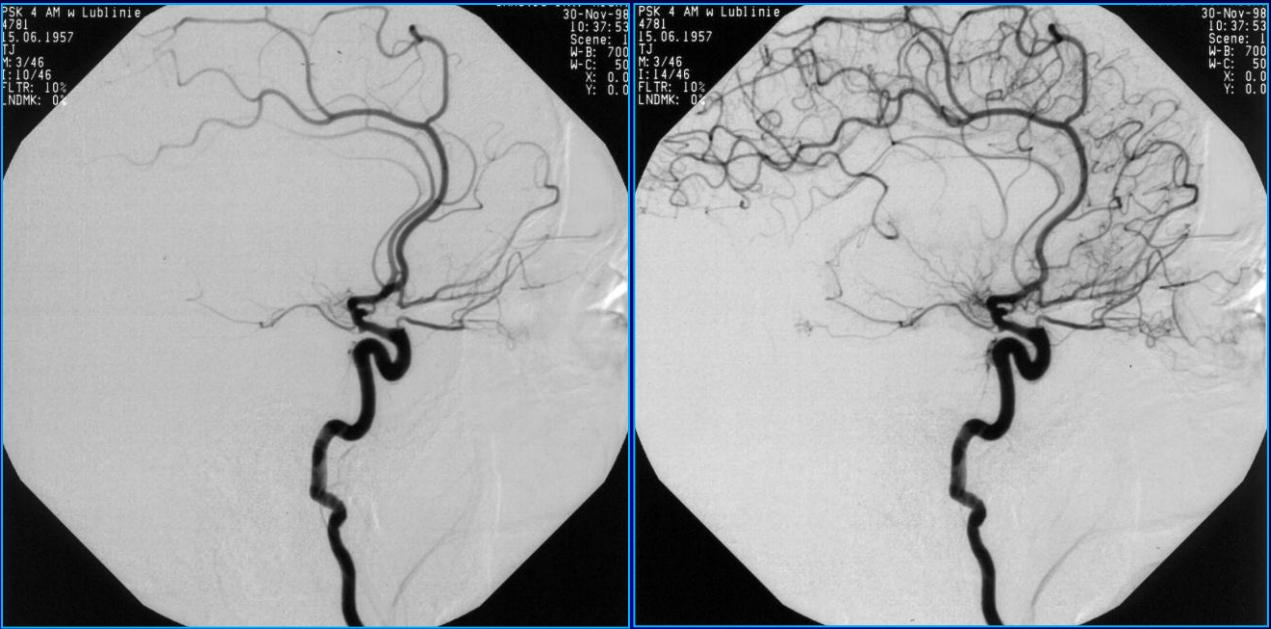
other sources of arterial embolism:

- atherosclerotic debris
- aneurysm's periwall thrombi
- foreign bodies (catheters, guide wires)

cerebral
embolism

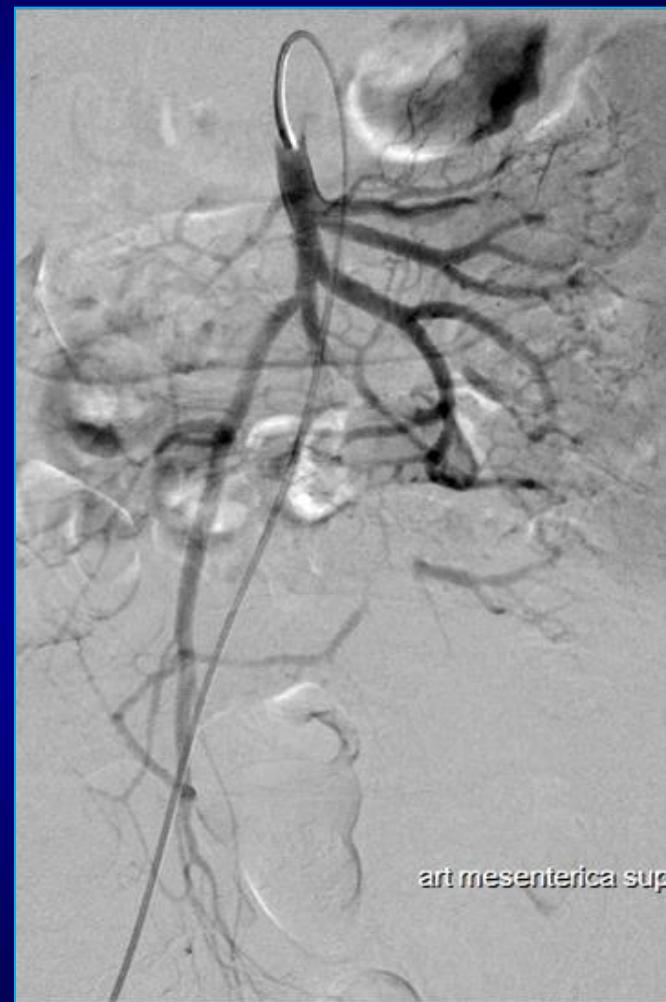
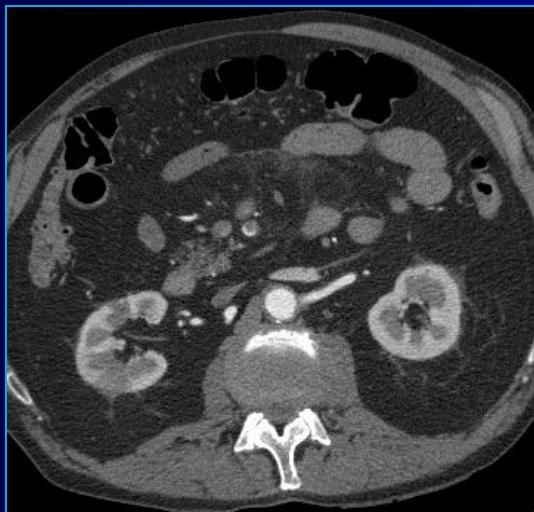
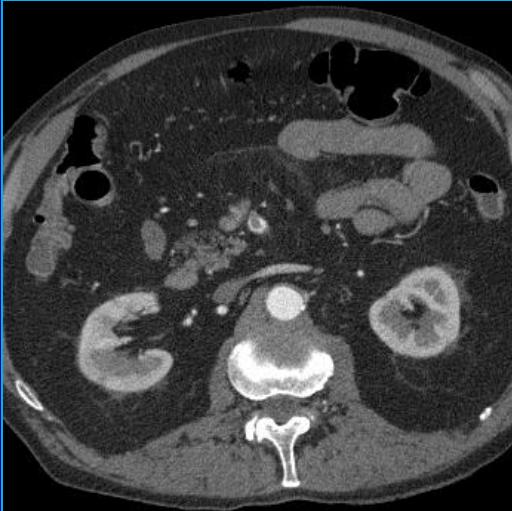


thrombo-embolic
occlusion of
middle cerebral
artery

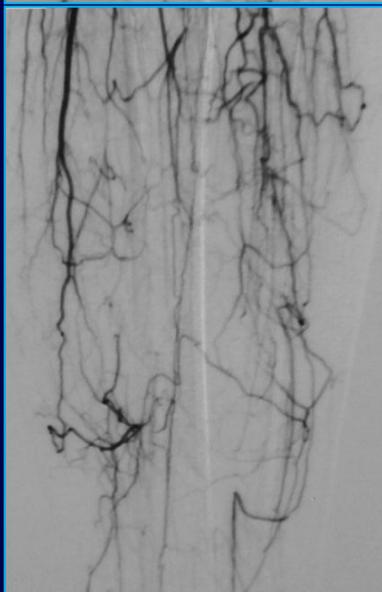


Abdominal angina

embolism of superior mesenteric artery



Peripheral embolism popliteal and SFA



6. Compresion syndromes

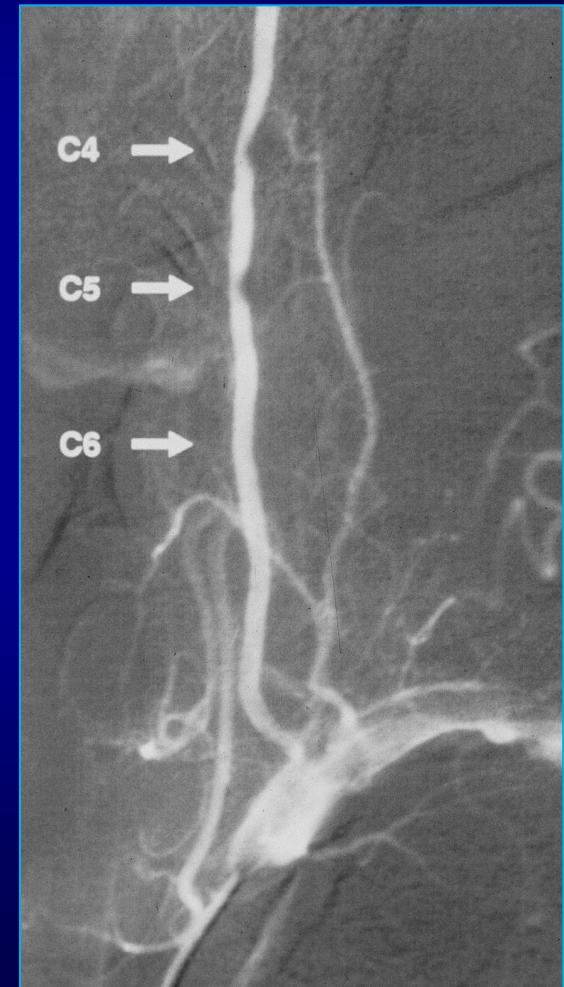
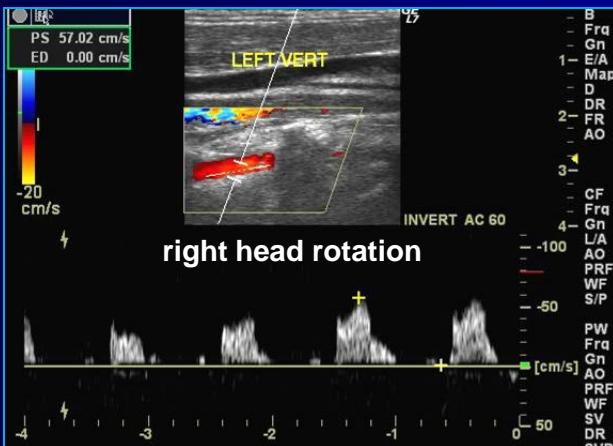
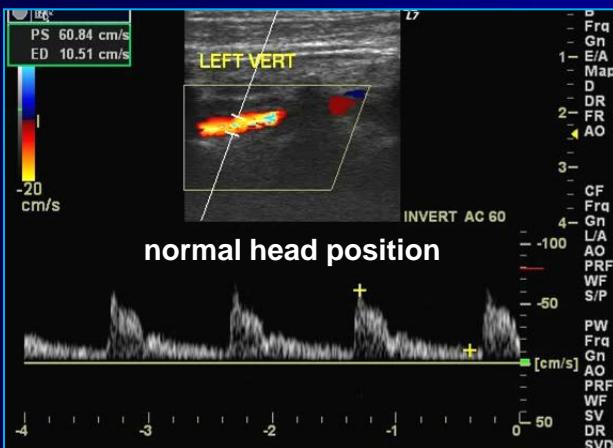
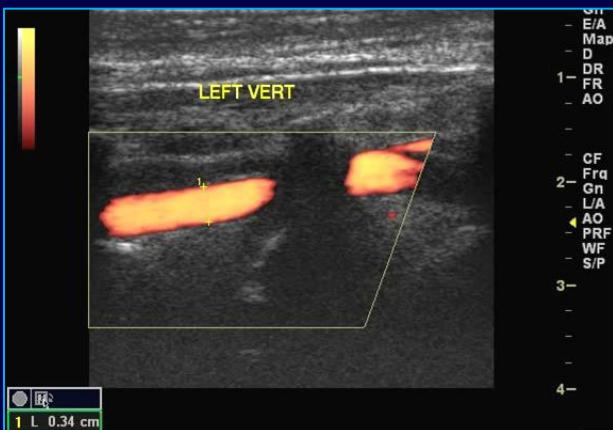
thoracic outlet syndrome

dynamic evaluation – Adson's manouver



Vertebral artery compression

may cause
vertebro-basilar insufficiency



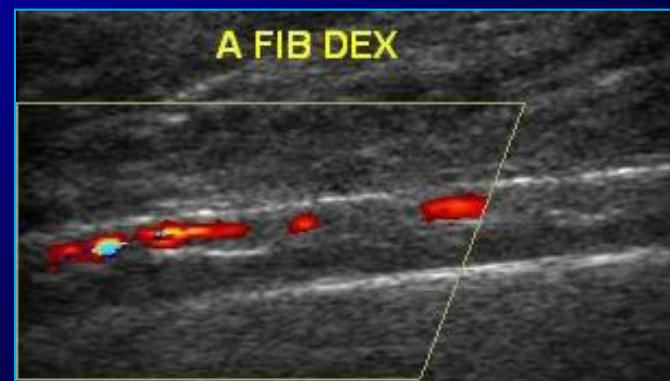
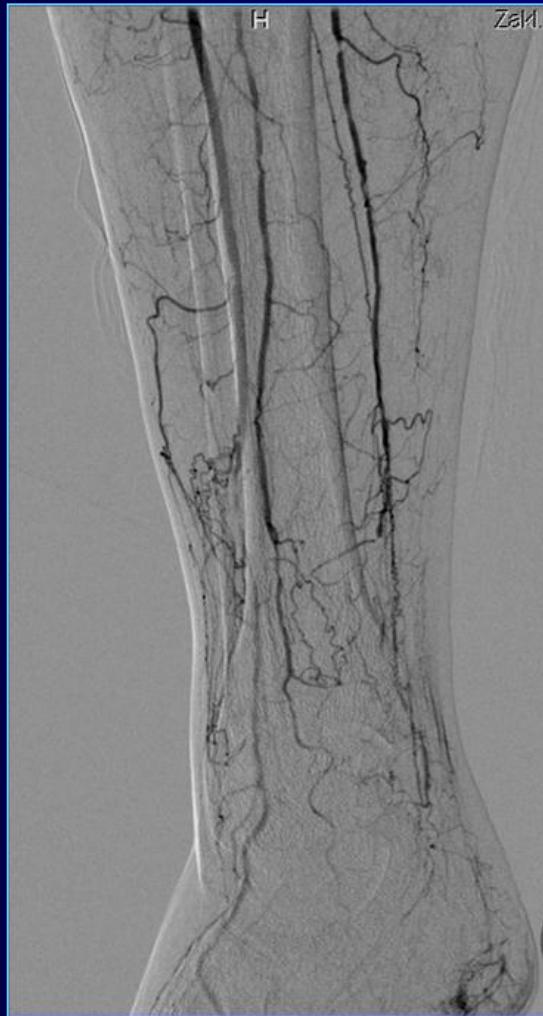
7. Angopathies in systemic diseases

- Diabetic macroangiopathy
 - intensifies atherosclerosis
 - affects small peripheral arteries
 - may damage intra-renal arteries

- Angiopathy in arterial hypertension
 - intensifies atherosclerosis
 - may cause arterial tortuosity
 - favourable for aneurysms / arterial ectasia

Diabetic macroangiopathy "diabetic foot syndrome"

- multilevel stenosis / occlusion of below-the-knee arteries
- typical wall calcifications / poor collateral circulation





The patient with type I diabetes & chronic arterial hypertension

renal macroangiopathy



chronic renal failure



8. Genetic vascular syndromes

Collagen synthesis disorders

- Marfan syndrome
- Ehlers-Danlos syndrome
- other / not-classified



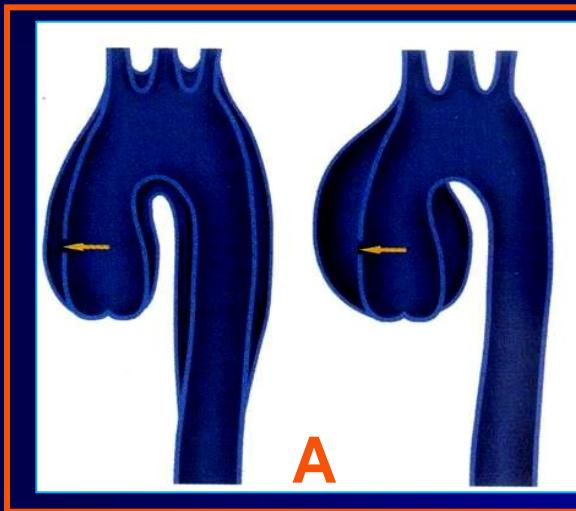
- aortic dissections
- aortic aneurysms
- peripheral aneurysms

Congenital hemangiomatosis

- Rendu-Osler-Weber syndrome
- Kasabach-Meritt syndrome
- other / not-classified

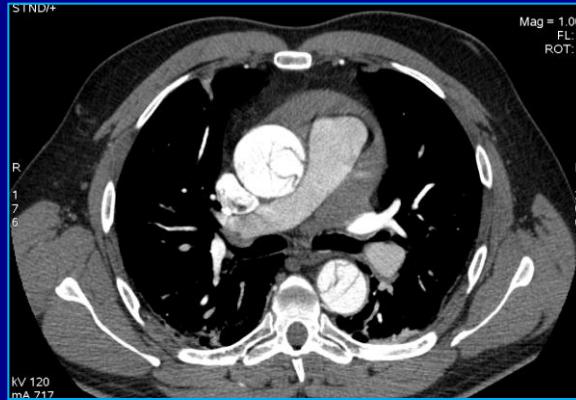
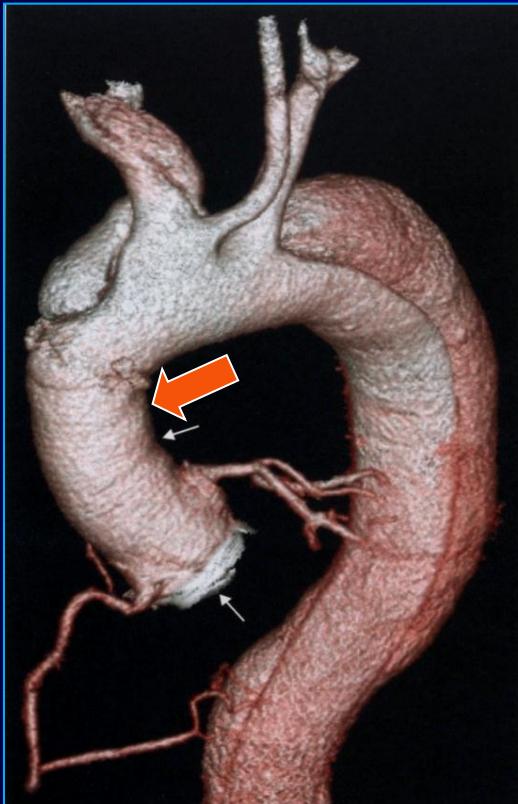


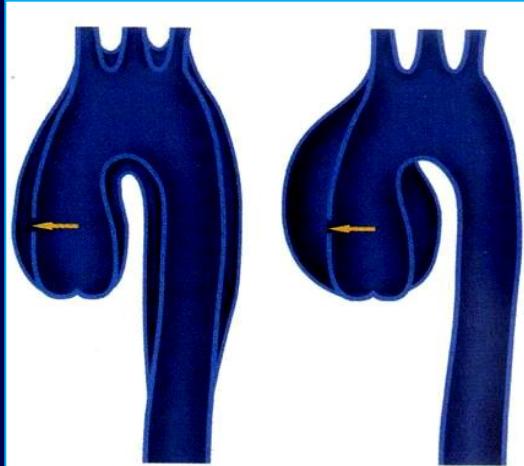
- pathologic vessels
- aneurysms / a-v fistulas
- liver, spleen, kidneys, lungs



Aortic dissection

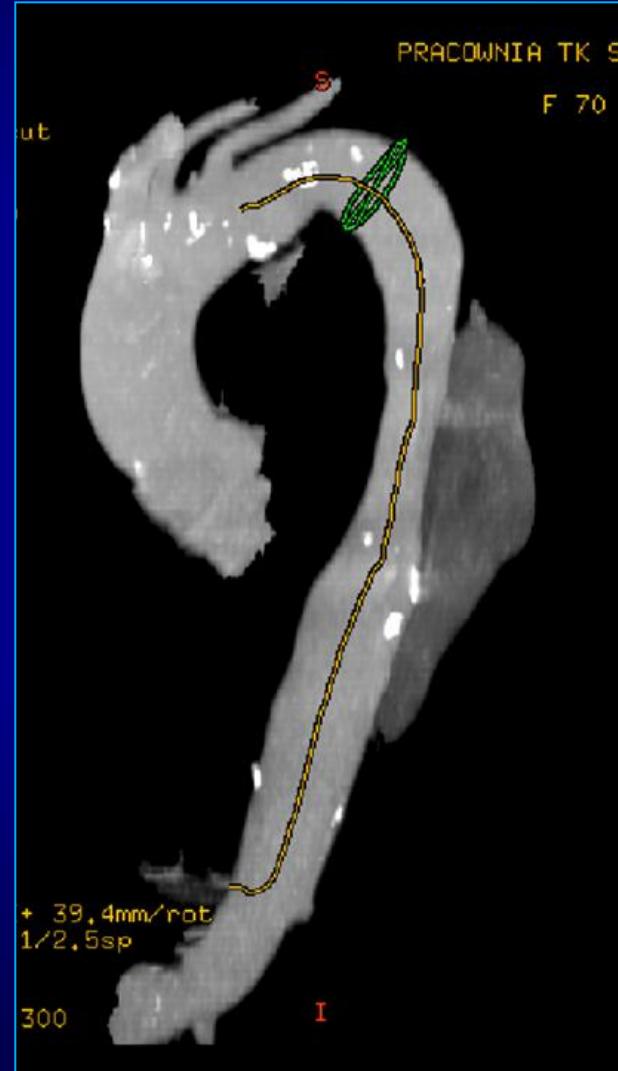
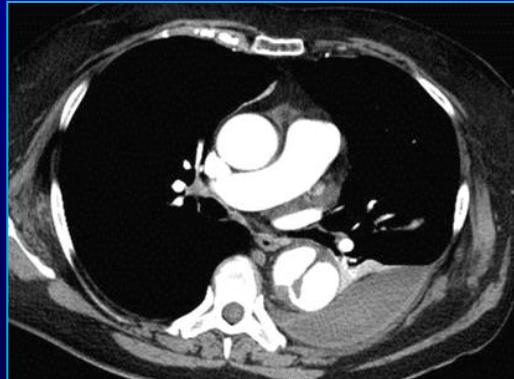
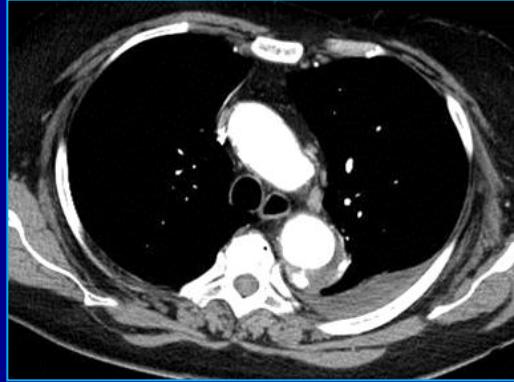
Stanford classification A



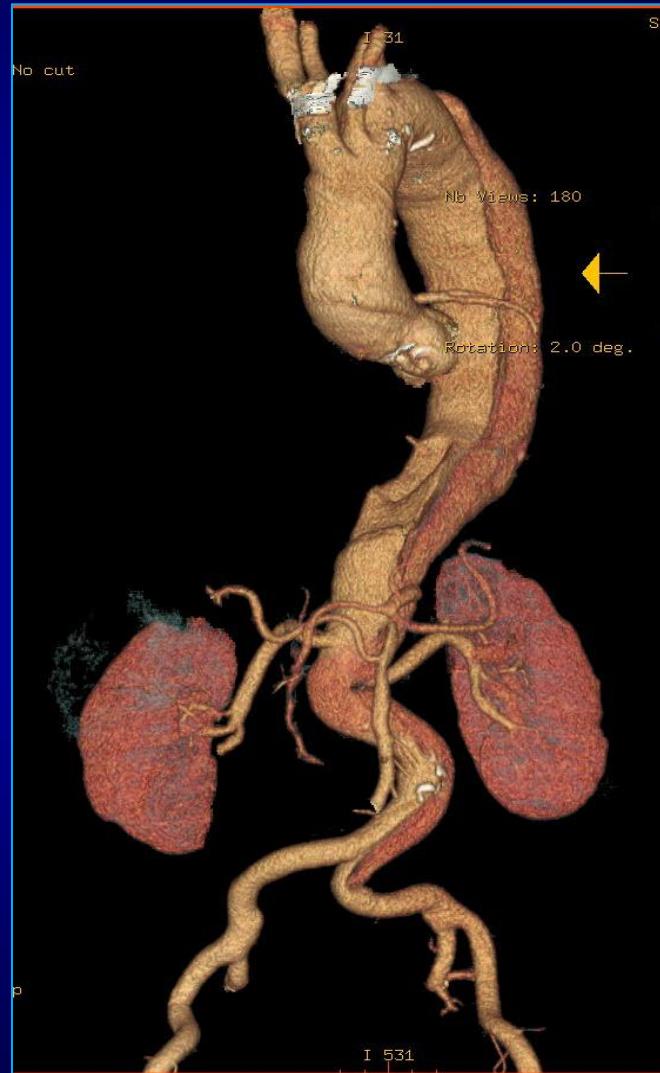


Aortic dissection

Stanford classification B



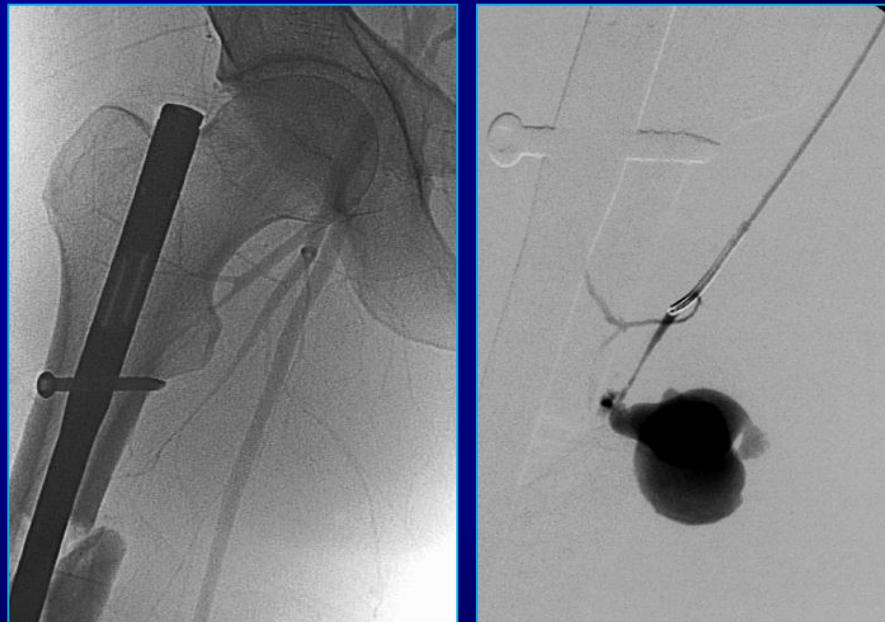
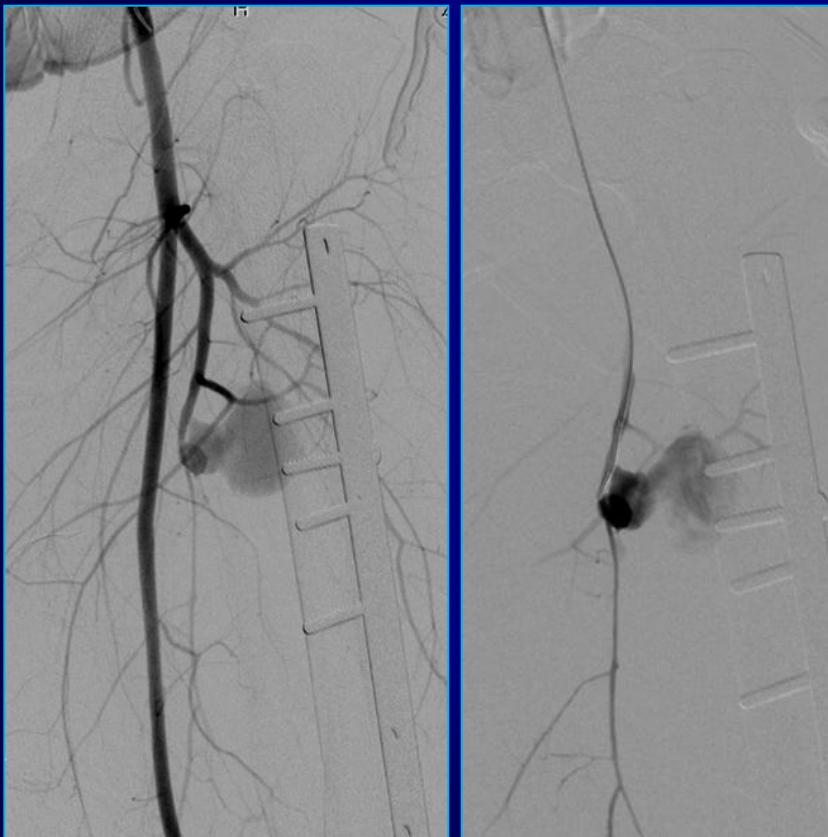
Aortic dissections / aneurysms in Marfan's syndrome



9. Arterial injuries

external or iatrogenic

- arterial obstructions
- artery rupture - bleeding
- false aneurysms (pseudaneurysms)
- arterio-venous fistulas



Post-traumatic artery rupture



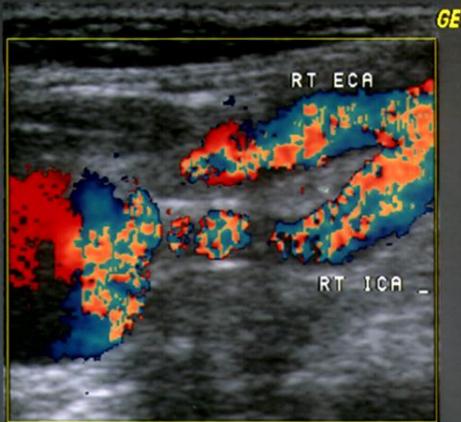
facial injury

*ECA pseudoaneurysm
& epistaxis*



Quad accident – crushed ankle
fibular artery rupture





Post-traumatic ICA aneurysms

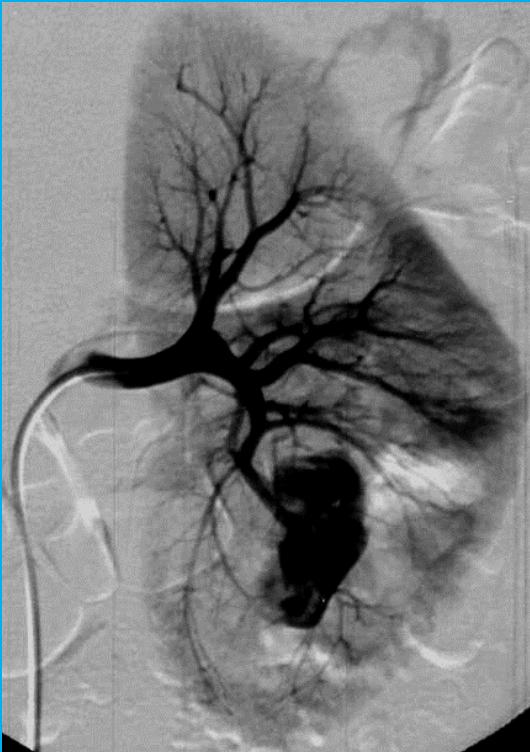
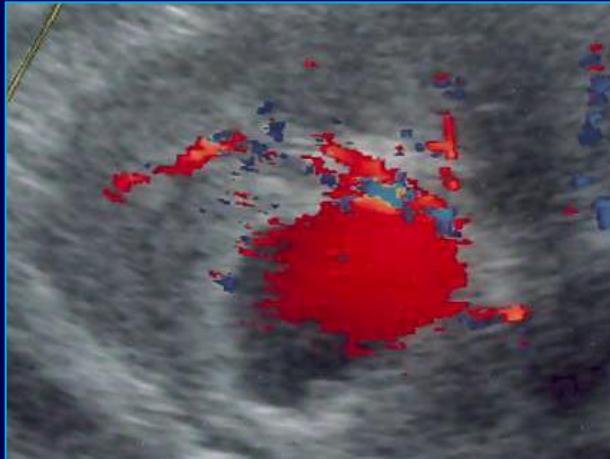
local trauma / possible stroke



ICA pseudoaneurysms

remained after post-traumatic dissections





iatrogenic pseudoaneurysms

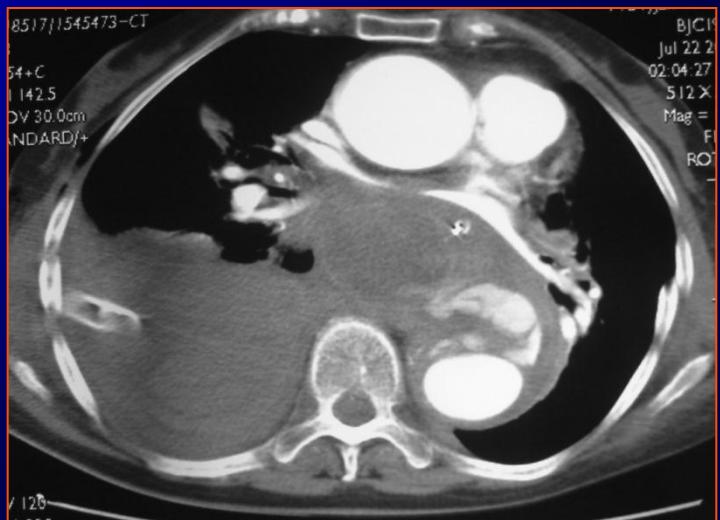
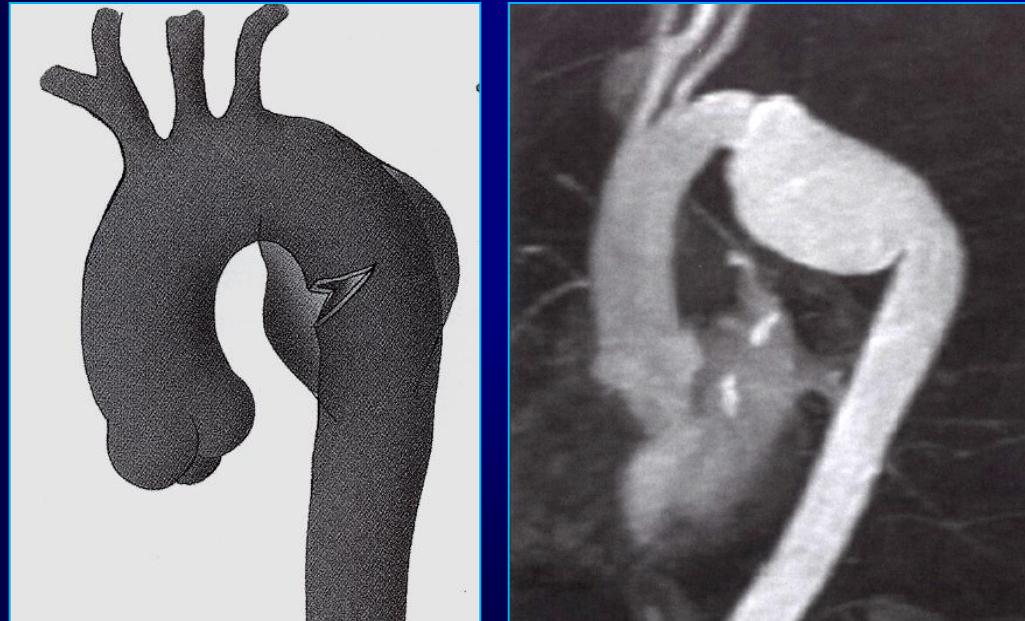
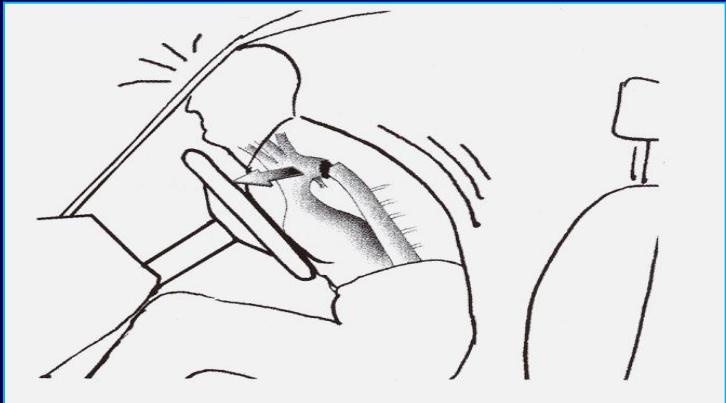
in kidneys → hematuria



after diagnostic biopsy

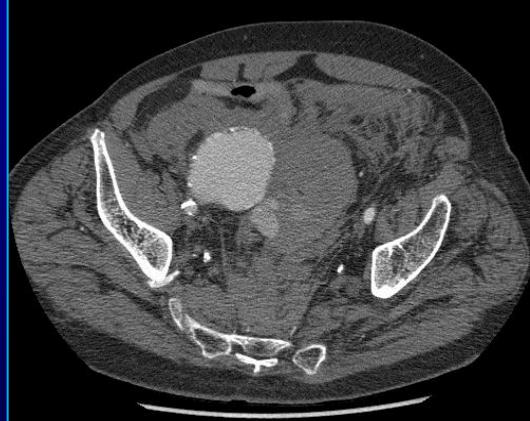
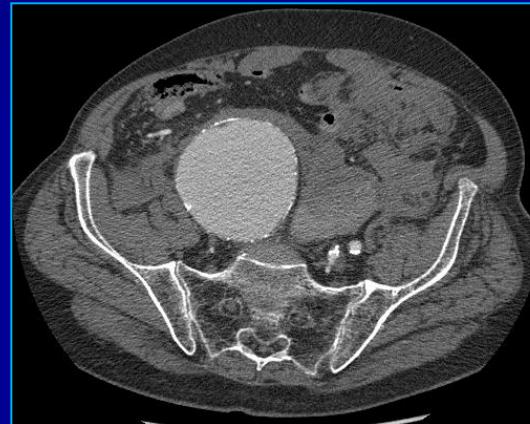
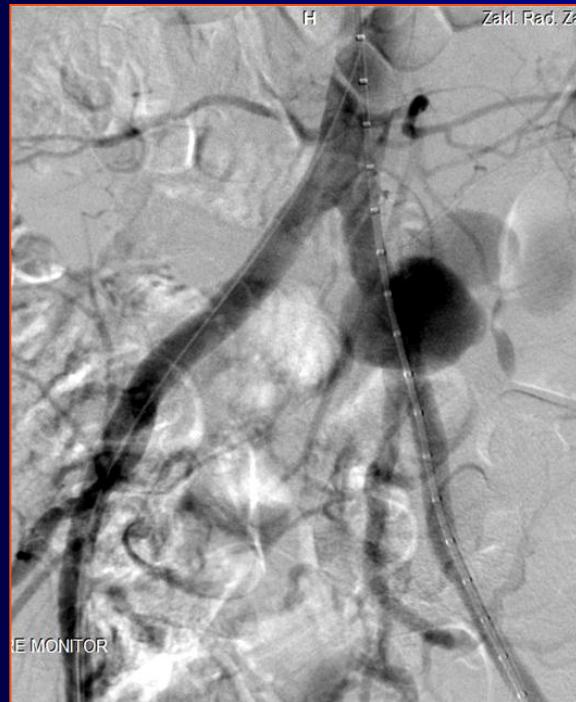
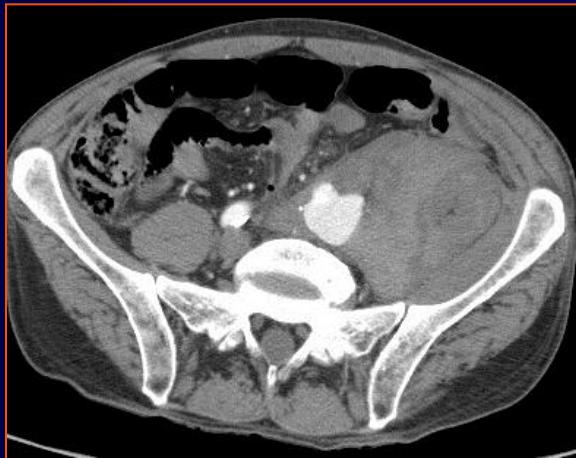


Post-traumatic, false TAA *(typical location)*



False iliac aneurysms

- penetration arterial injury
- abdominal crush



Iatrogenic PAs after femoral artery puncture

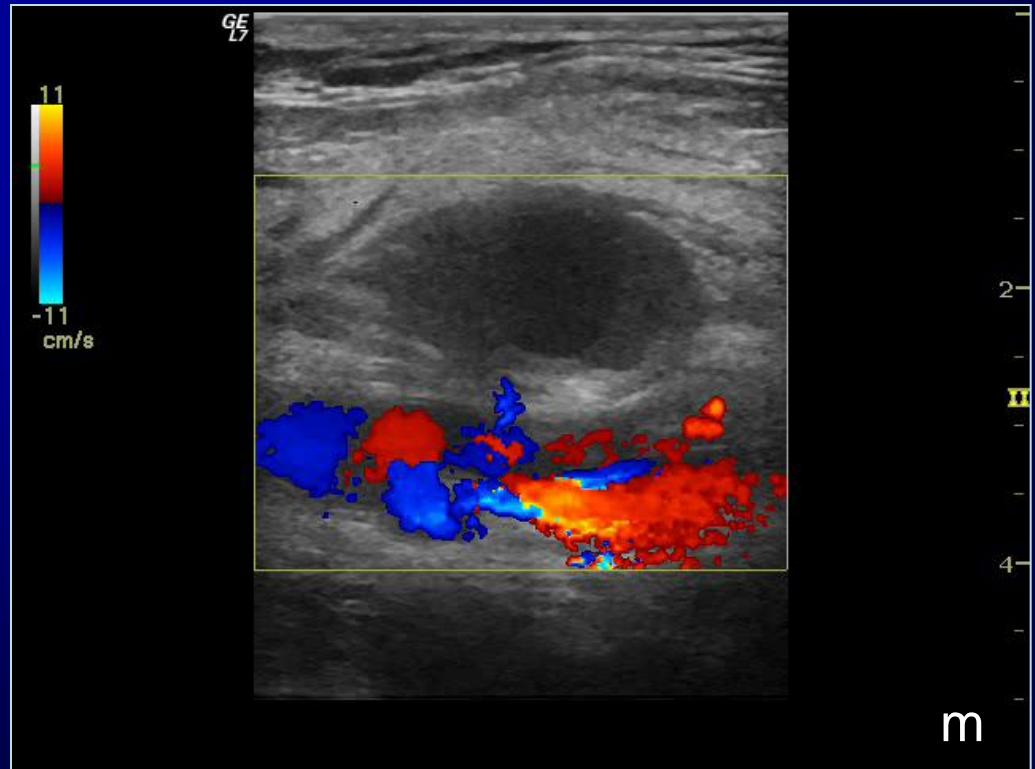
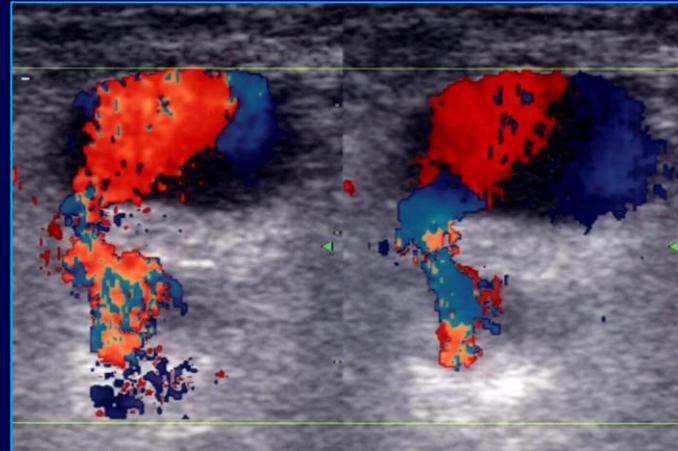
growing importance !!!



thousands of diagnostic & therapeutic
minimally-invasive endovascular procedures



PA is the most common complication



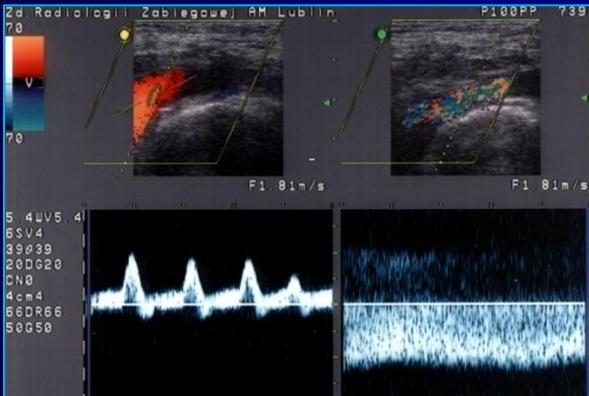
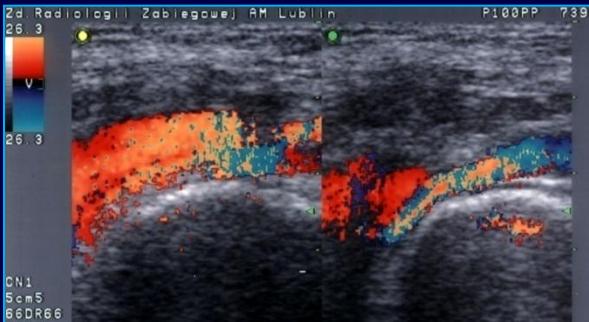
Post-traumatic a-v fistula

iatrogenic

after femoral artery puncture



external trauma
motorbike accident



II. Venous pathology

less common than arterial diseases?

- DVT – deep venous thrombosis
- Varices – valvular incompetence
- Venous obstruction (stenosis / thrombosis)
 - external compression
 - venous wall infiltration
 - iatrogenic (venous access / electrostimulation)
- Trauma

DVT – deep venous thrombosis

the most important venous disease ?

Etiology:

- Idiopathic / spontaneous
- Long-term immobility
- Thrombotic disorders (deficit)
- Neoplastic diseases
- Gravidity / hormonal therapy (contraceptives)
- External compression (prolonged)
- Trauma / iatrogenic

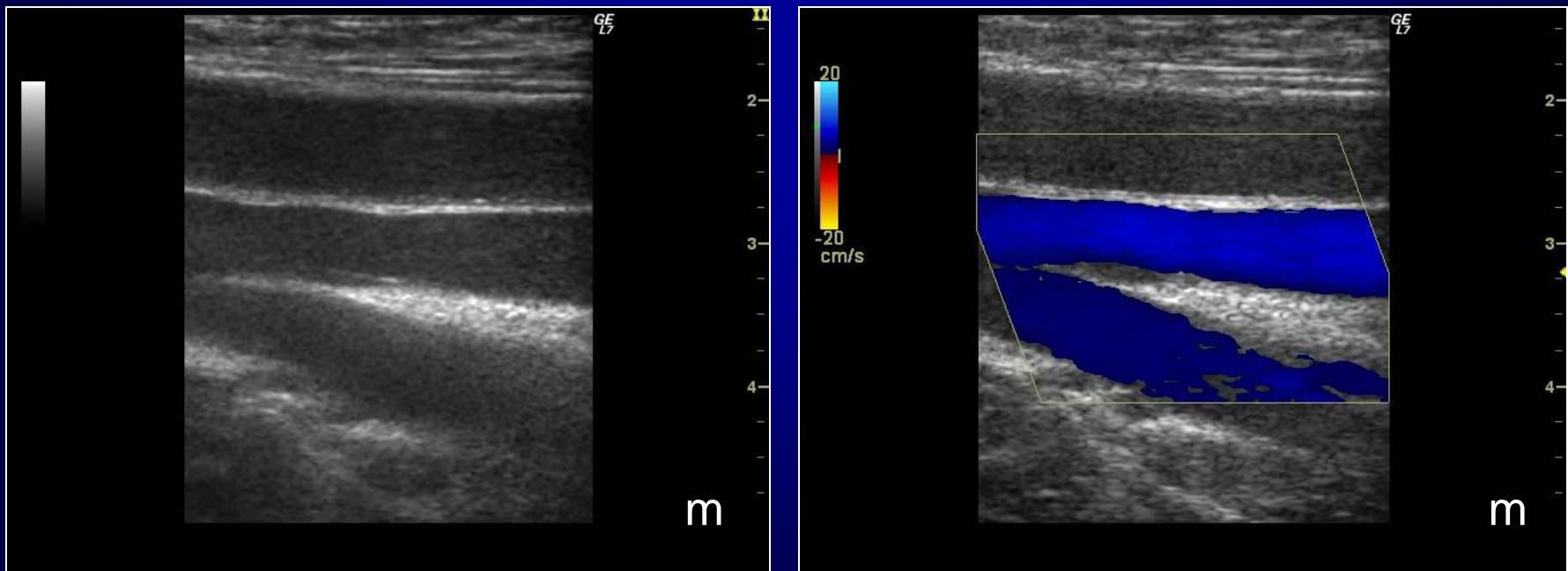
DVT – mostly affects lower limbs deep veins !!!

Duplex Doppler ultrasonography (DDUS)

is the best non-invasive modality to evaluate peripheral veins

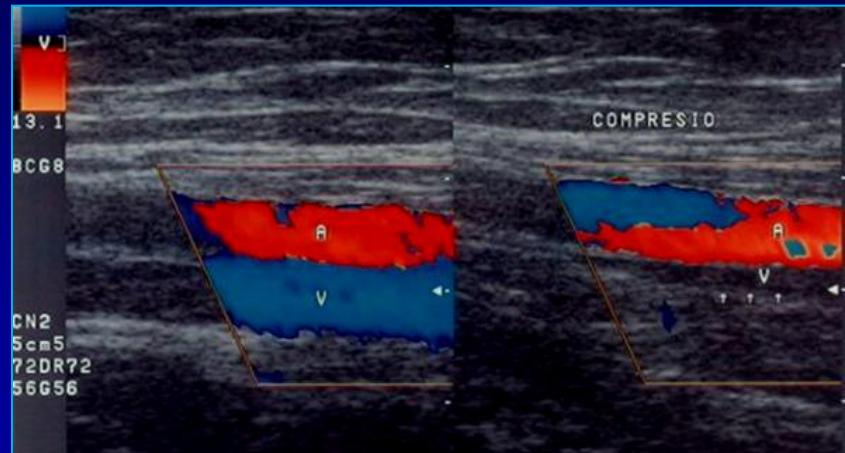
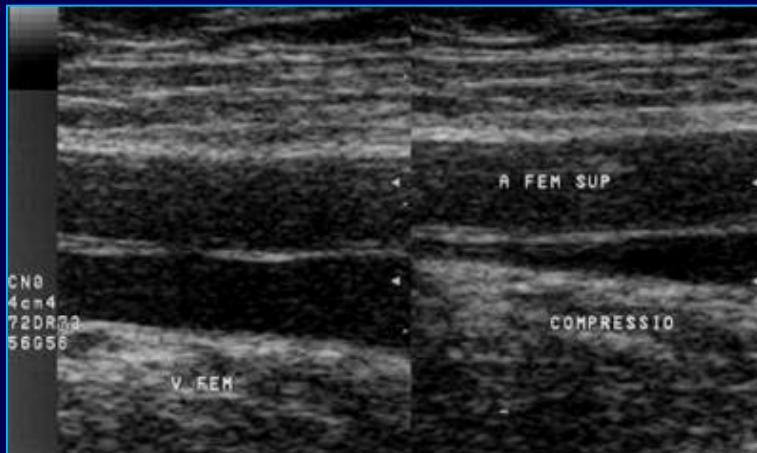


it combines real-time visualization of vein morphology
and the map of flow velocity and direction



Normal veins

- react for US probe compression
- Doppler signal of venous flow

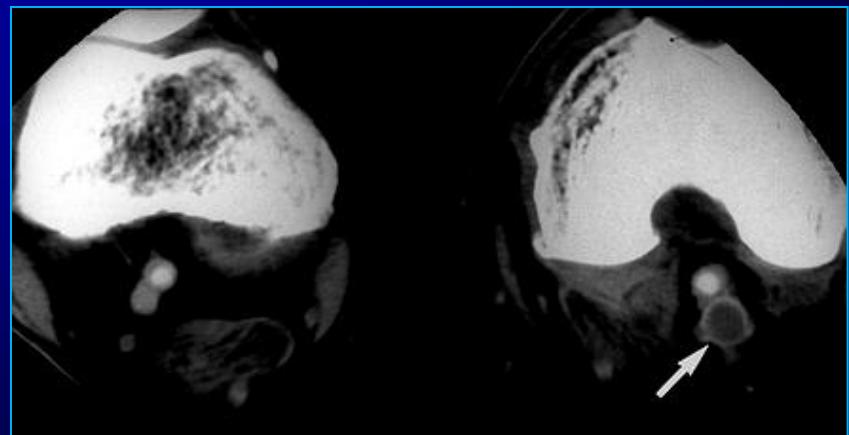
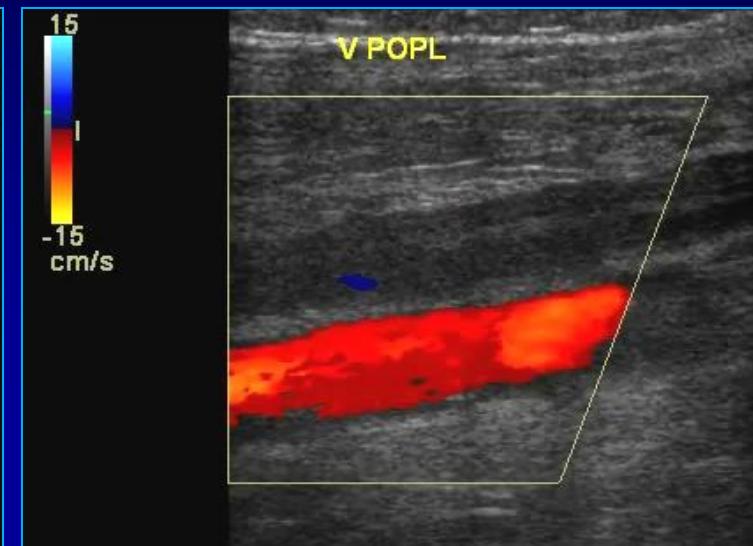
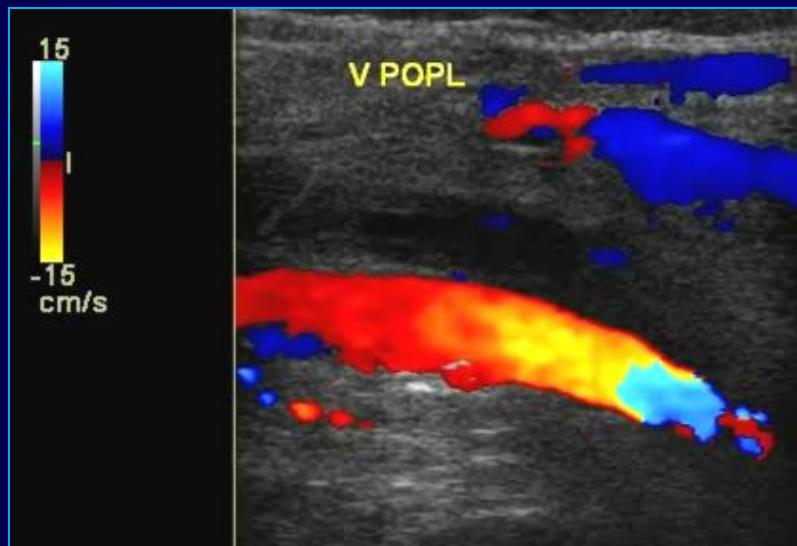


Thrombosed veins

- no compression reaction
- no flow signal



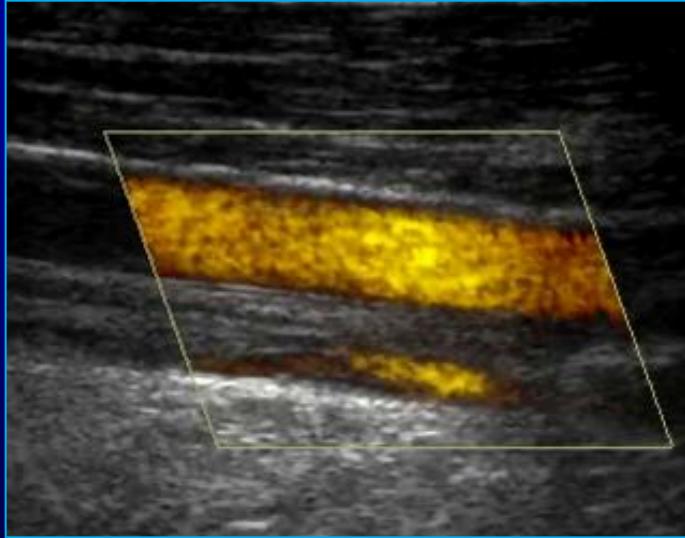
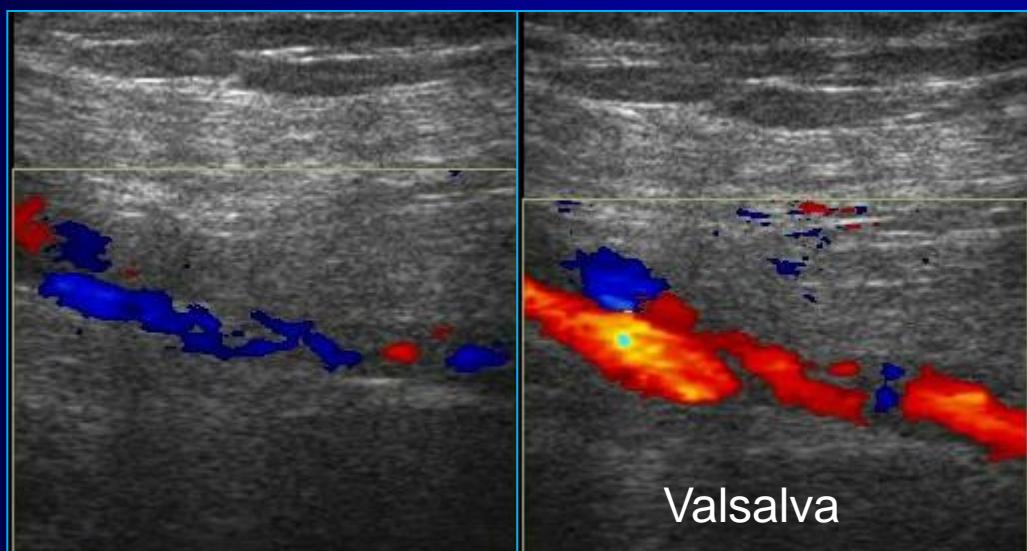
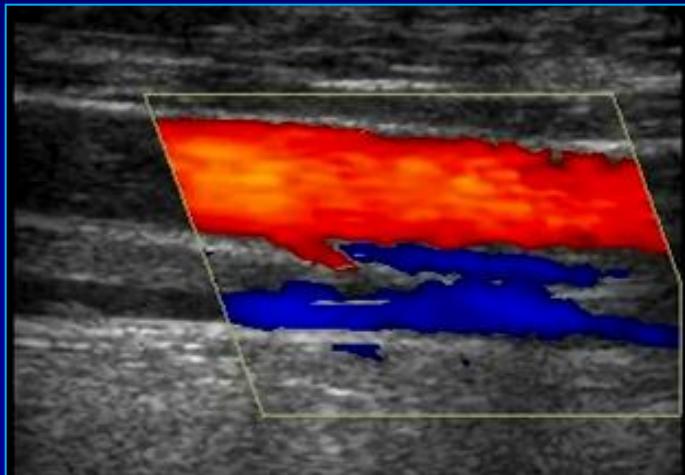
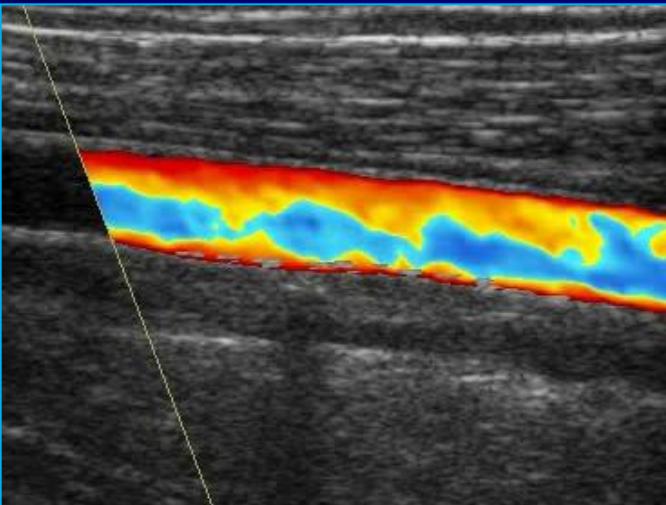
Popliteal vein thrombosis - easy to diagnose with US



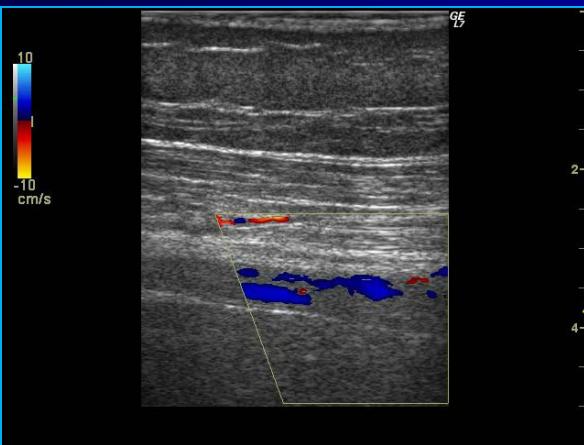
DVT → recanalisation

Duplex Doppler US

- to detect recanalisation
- to follow its progress
- to assess valvular incompetence



No further imaging (than US)
is needed to assess DVT recanalization



Infrapopliteal / calf veins thrombosis

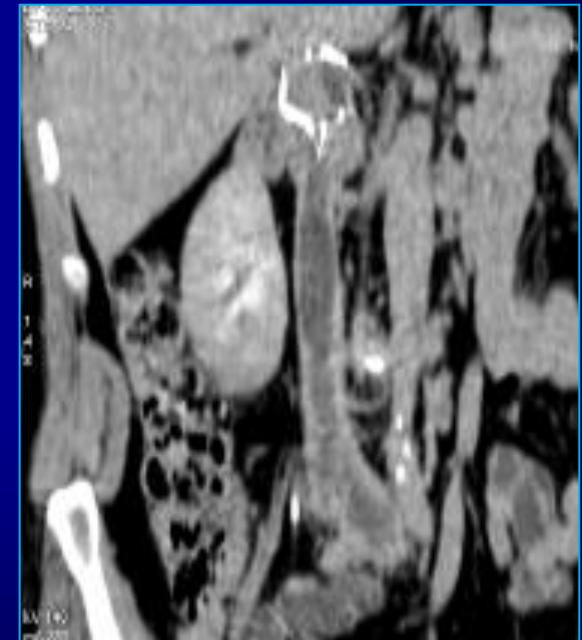
phlebography



- when duplex Doppler US does not give certain diagnosis
- patients highly suspected with DVT (crural oedema)

Central vein thrombosis

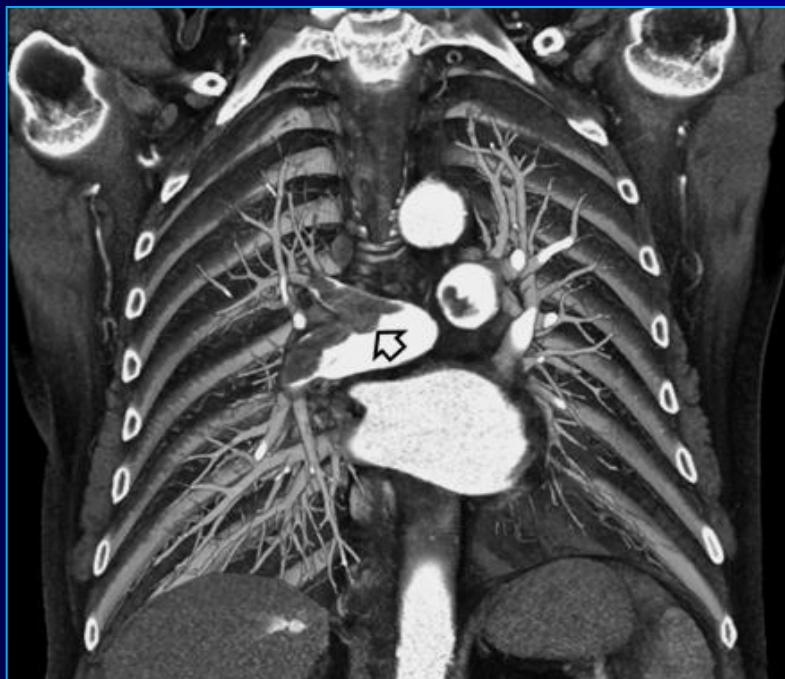
CT & angio-CT → a modality of choice





Pulmonary embolism

life-threatening condition





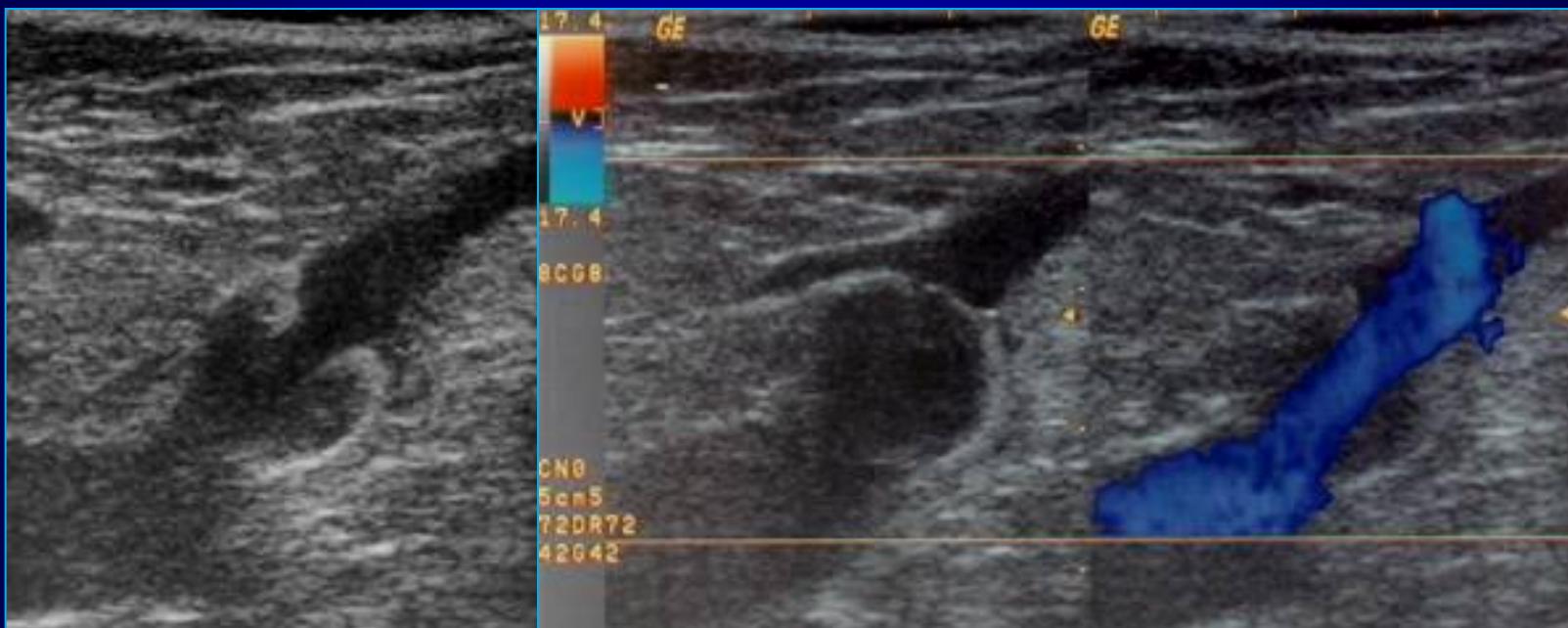
Crural varices

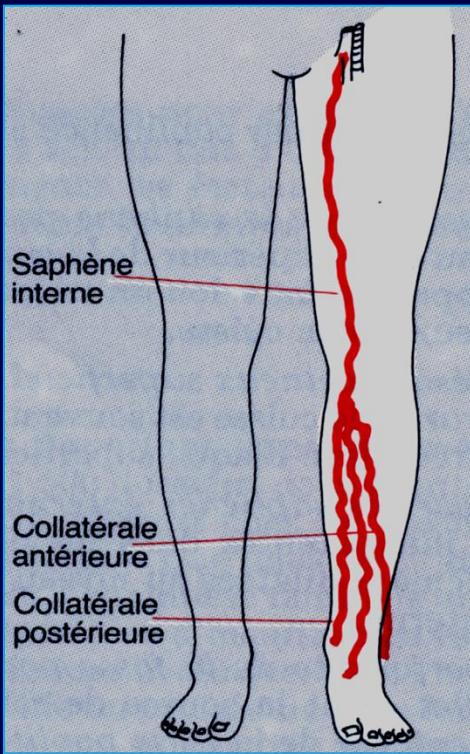
cosmetic disease ?

ethiology / pathogenesis of varices
is valvular incompetence (*genetic*)

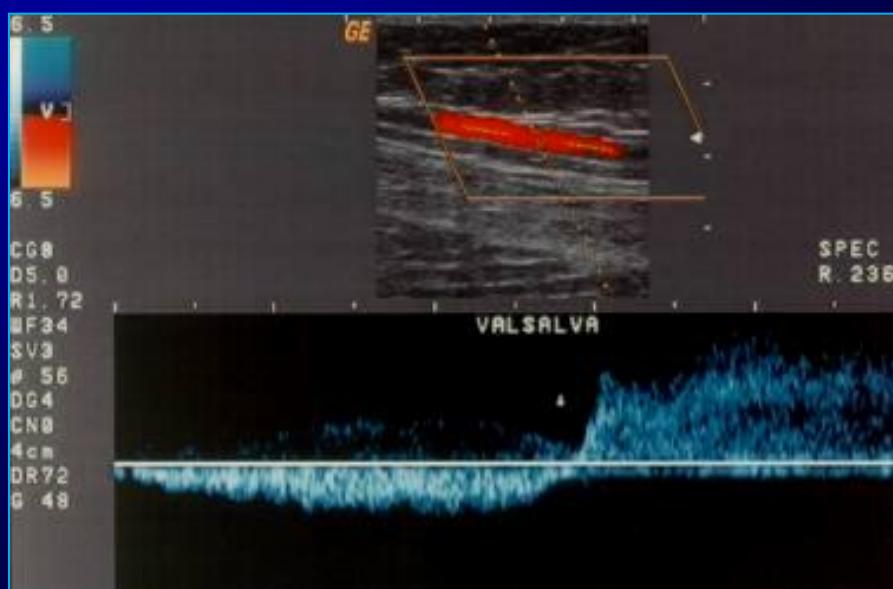
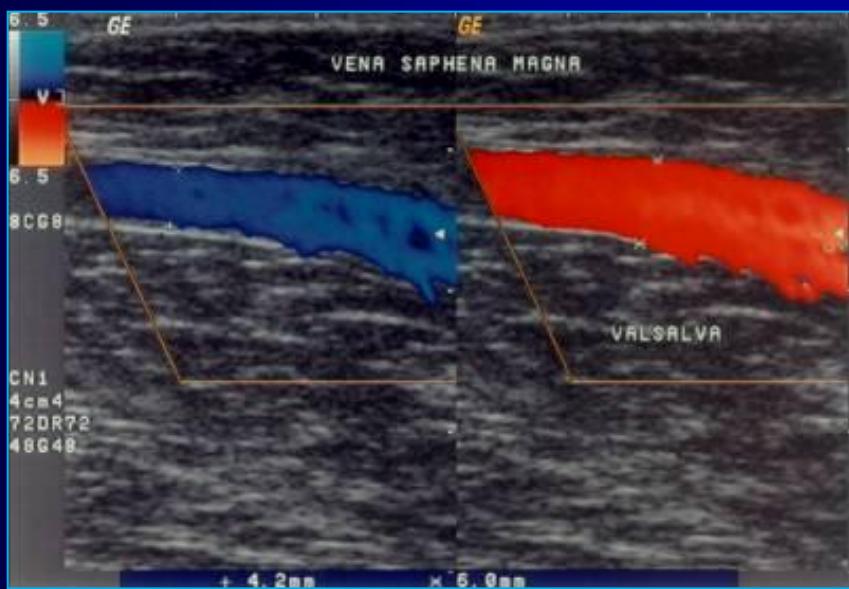
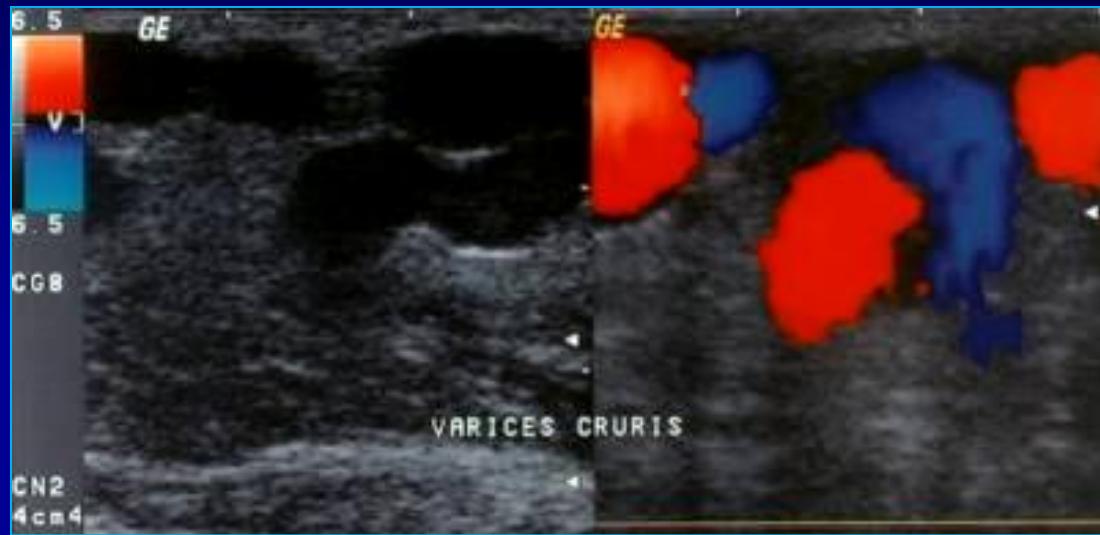


of great / small saphenous veins



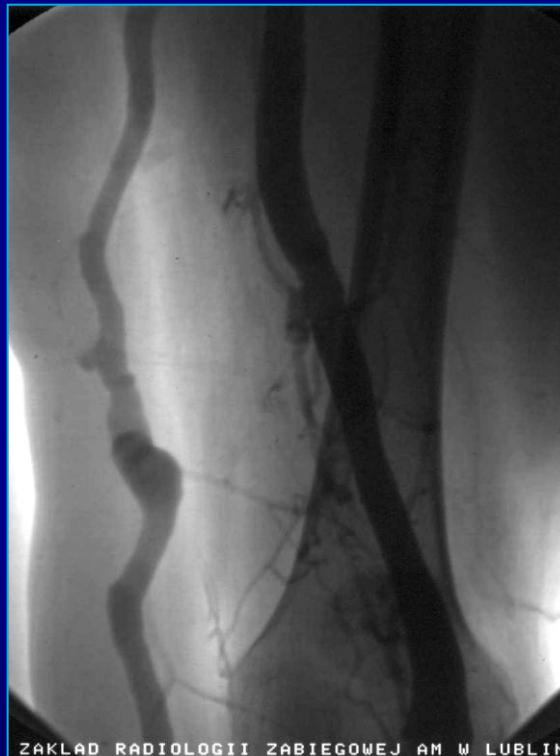


Crural varices duplex Doppler US



Crural varices

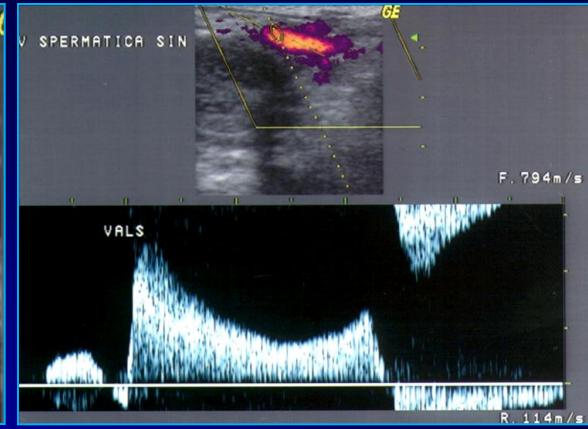
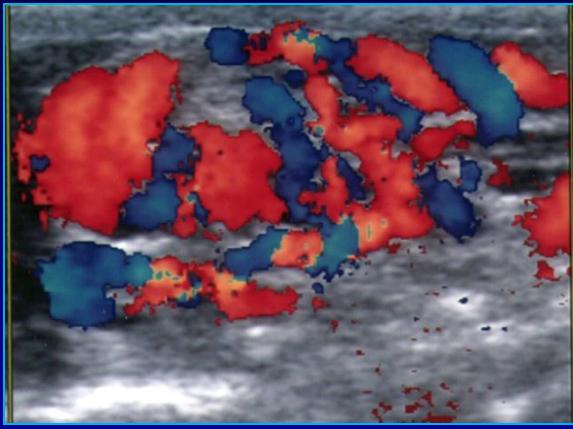
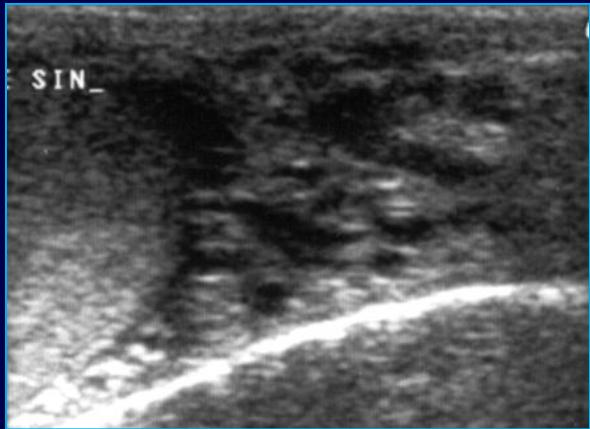
phlebography / venography is a history



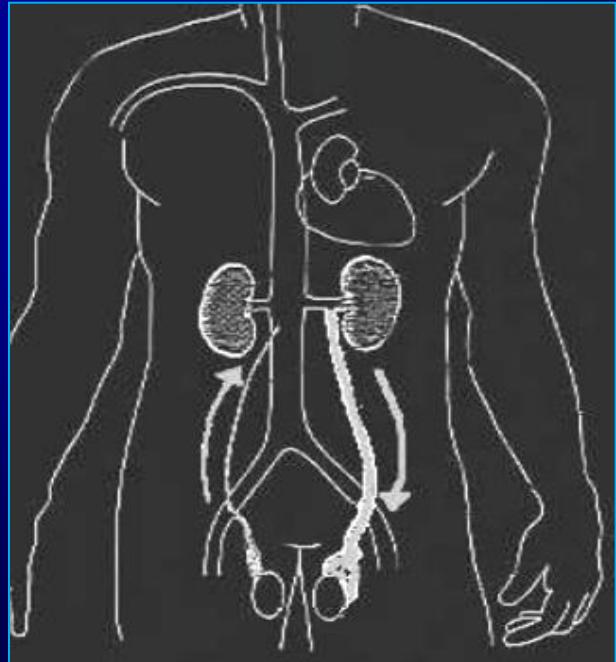
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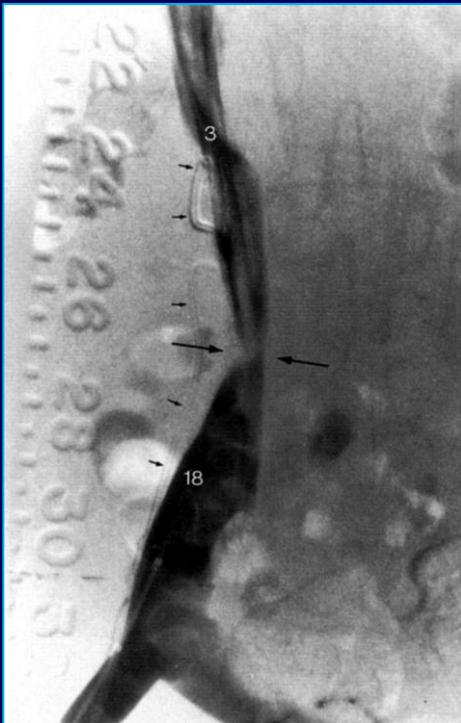


Varicocoele



IVC infiltration

in pancreatic carcinoma



IVC compression

retroperitoneal
lymphadenopathy



IVC syndrome

collateral circulation
via paravertebral plexus

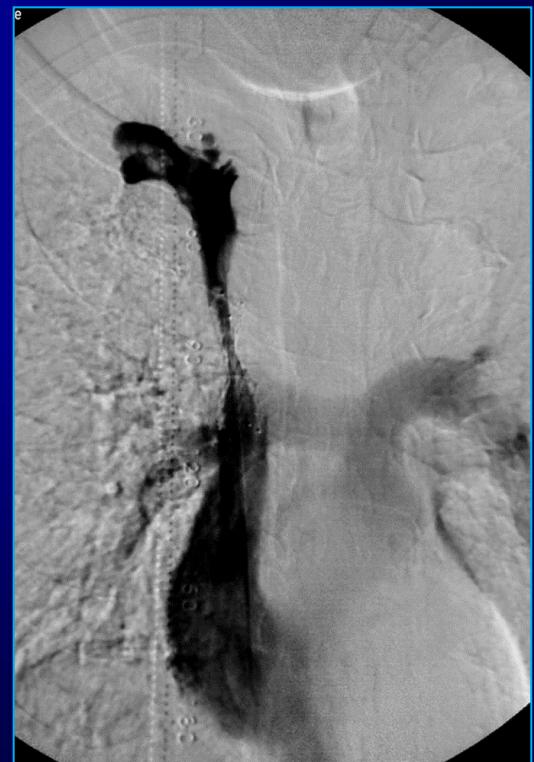
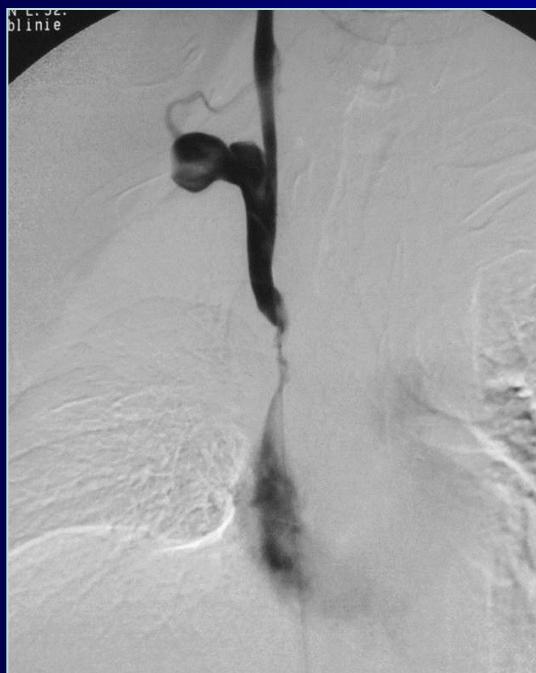


Stenosis of superior vena cava

VCS syndrome



most frequently because
of bronchial carcinoma



subclavian / brachio-cephalic vein stenosis

very frequently iatrogenic – after central venous access / heart stimulation

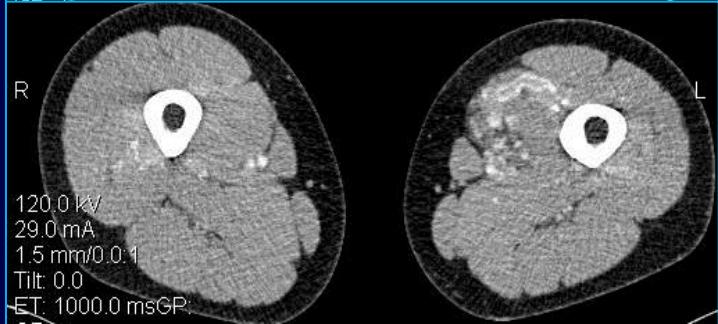
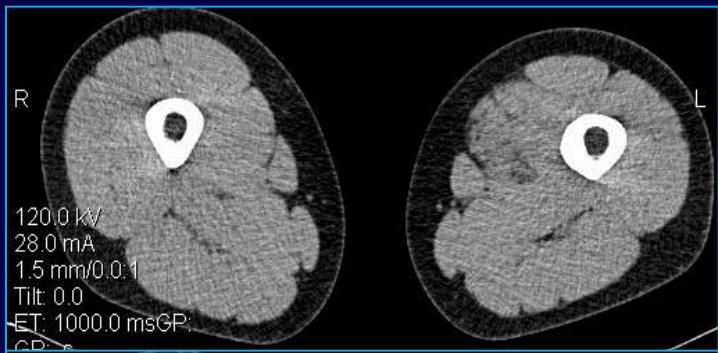


III. Hemangiomas / Vascular malformations

very heterogenous group of diseases

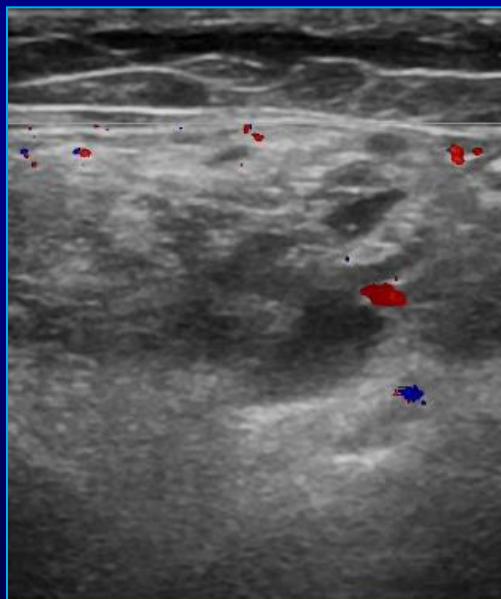
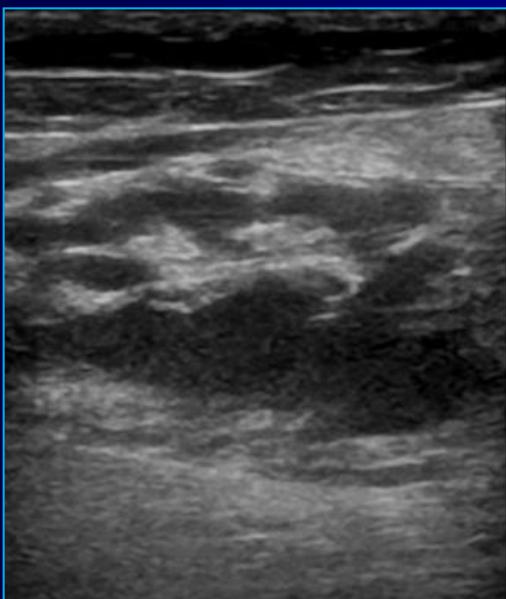
Basic classification:

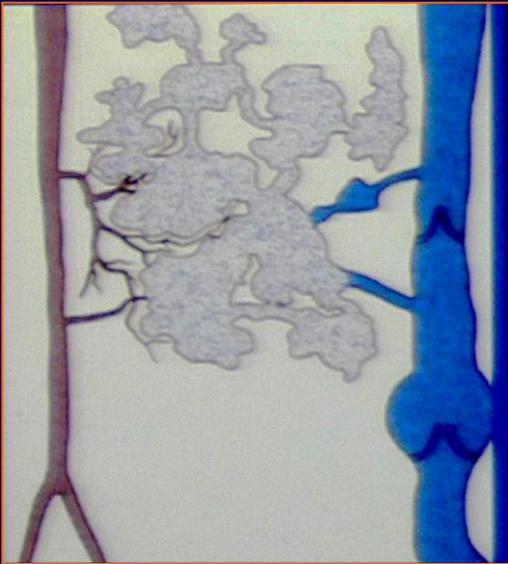
- Venous / lymphatic malformations
- Arterio-venous malformations
 - macrofistulous
 - microfistulous
- Isolated a-v fistulas



venous / lymphatic hemangioma

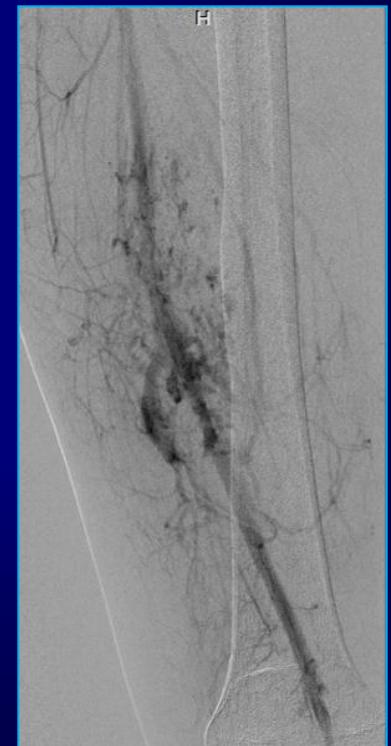
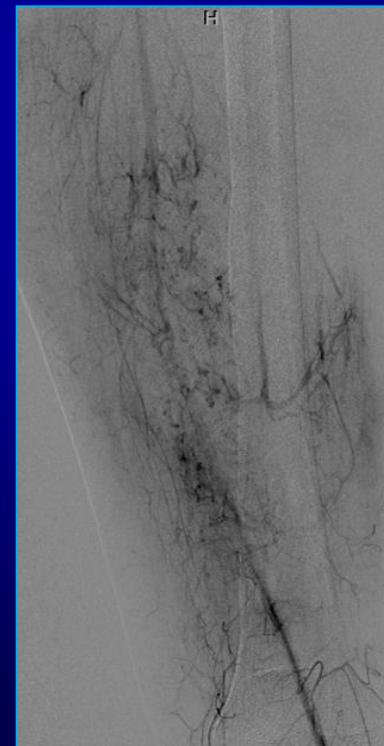
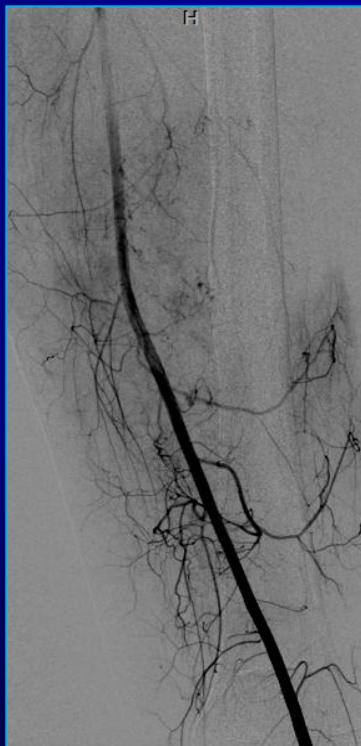
38 y.o. female
feeling pain during walking

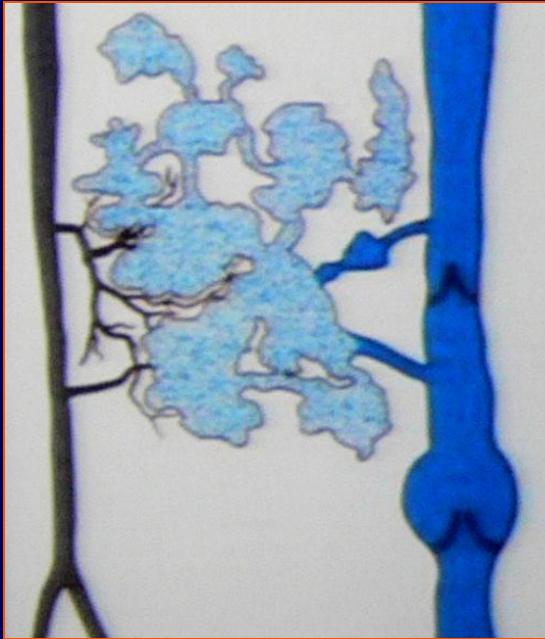




venous / lymphatic malformations

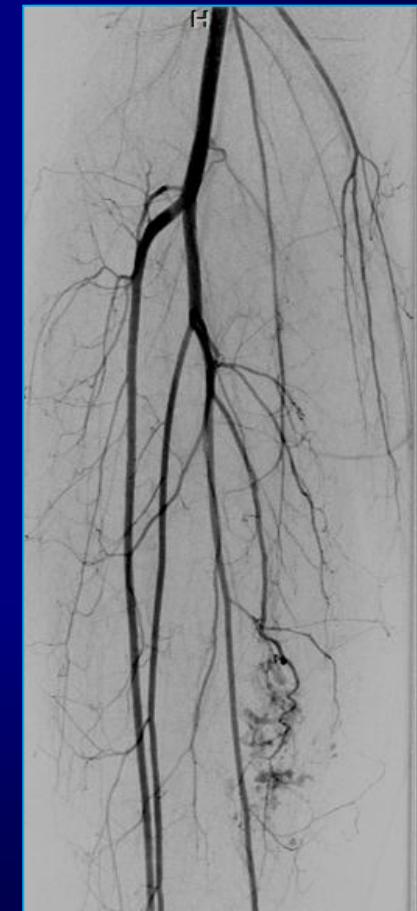
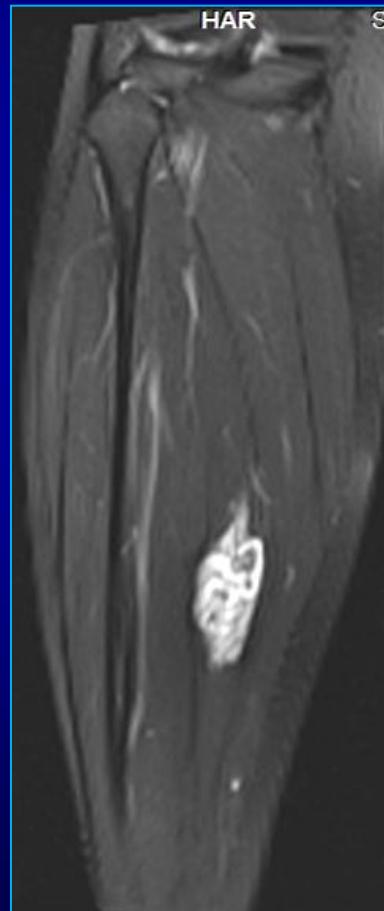
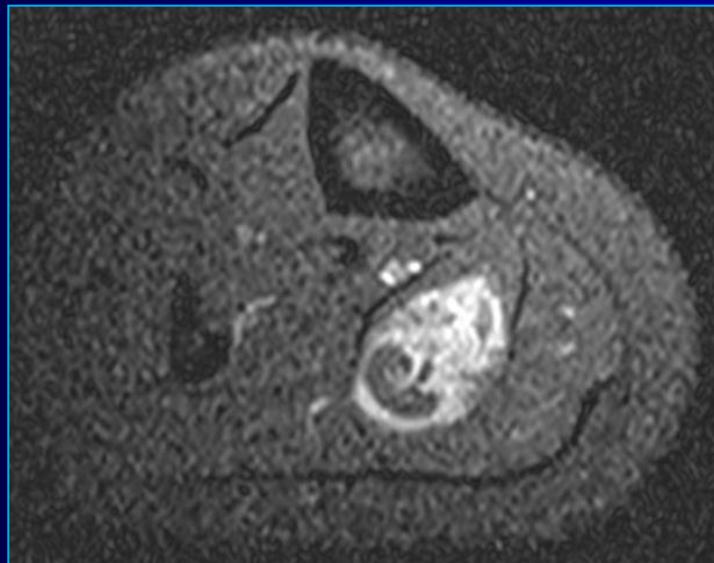
is angiography needed ?

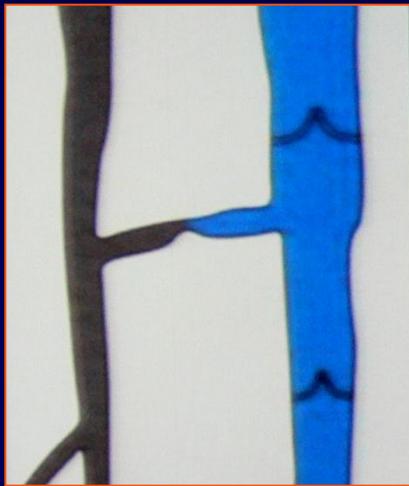




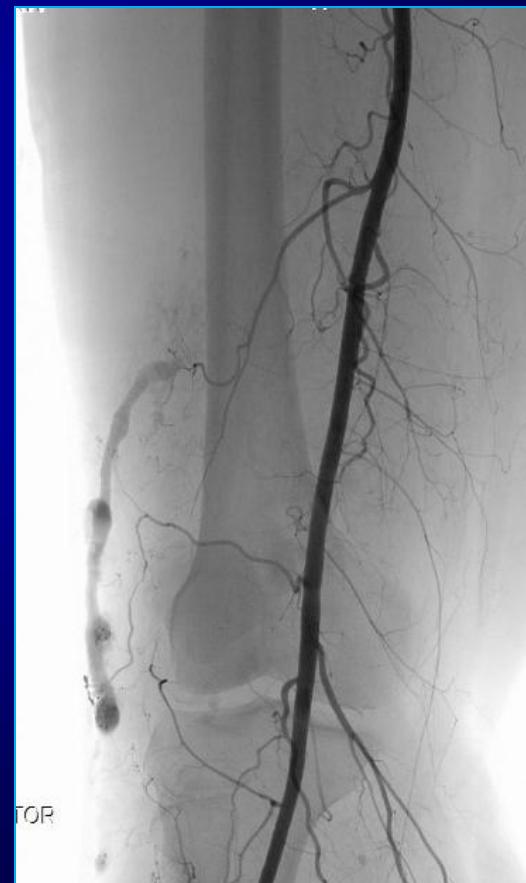
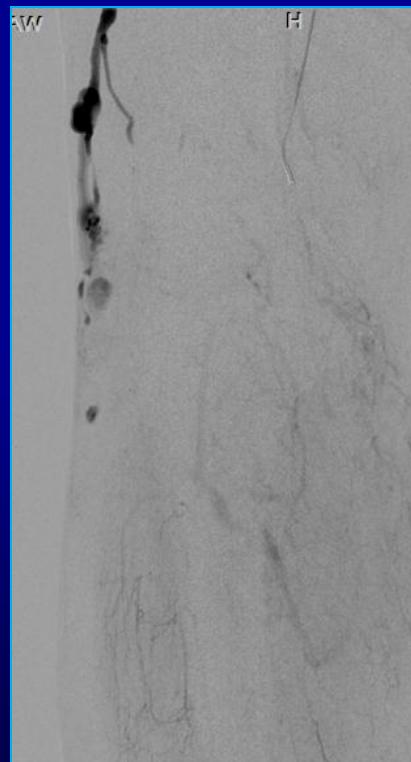
venous / arterio-venous hemangioma

microfistulous ?



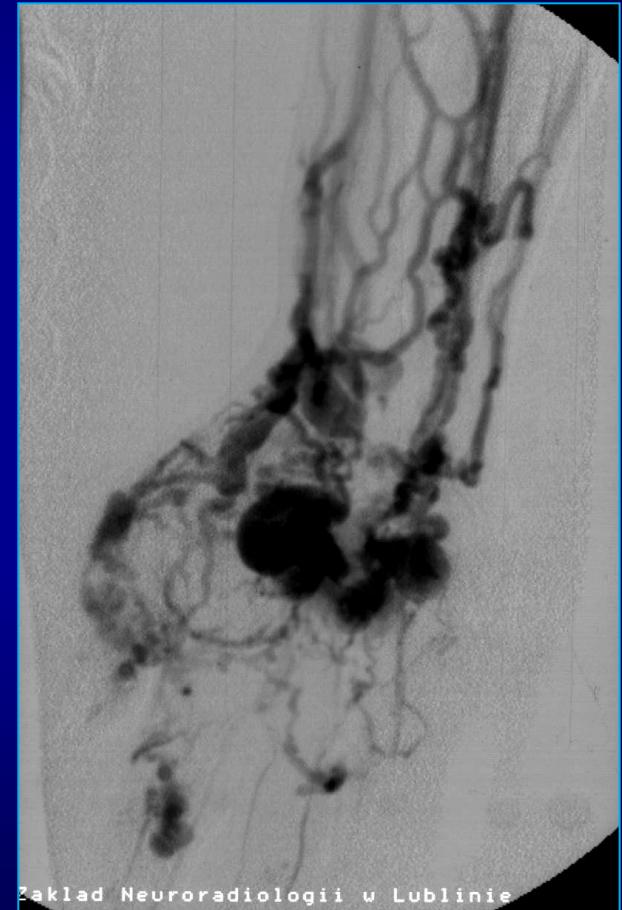
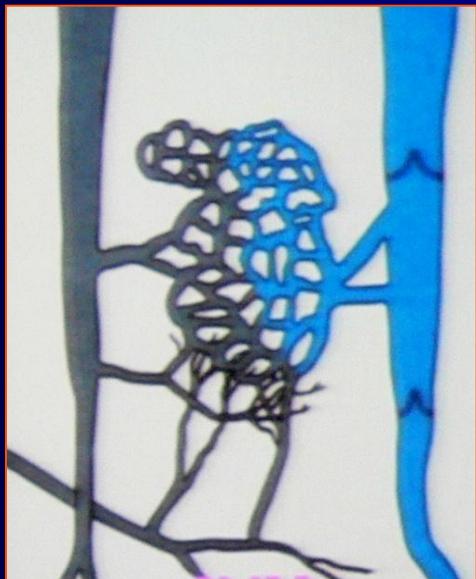


venous malformation
or
isolated i-v fistula ?



A-V malformation / hemangioma

arterial & venous phase of angiography

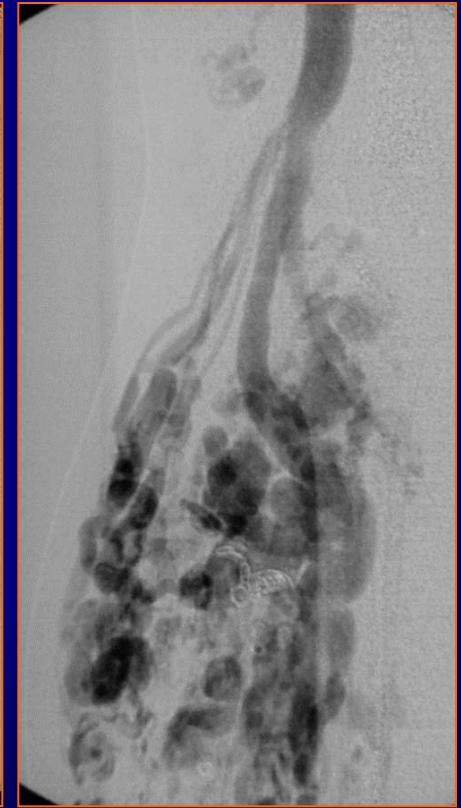
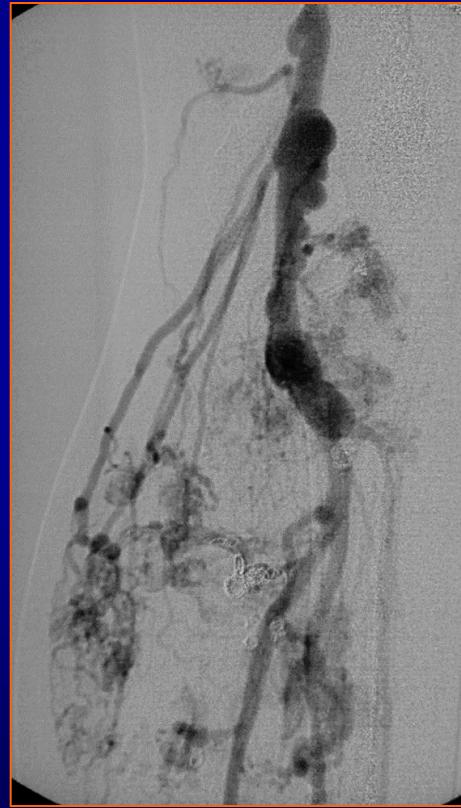
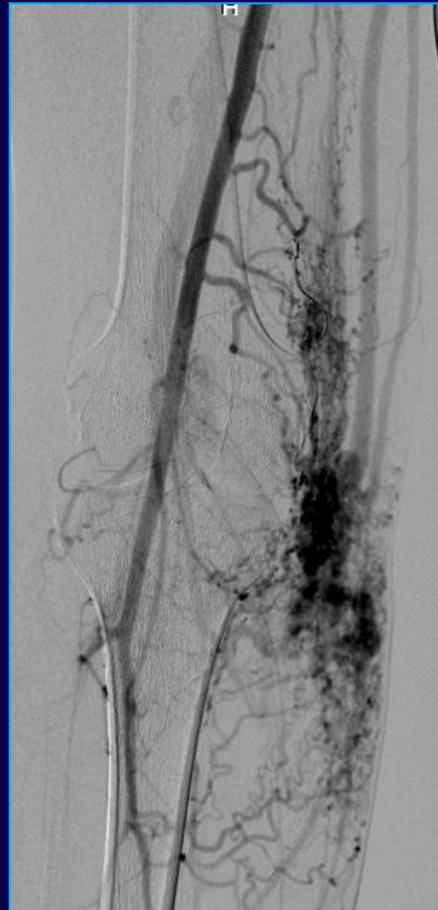


Zakład Neuroradiologii w Lublinie

Zakład Neuroradiologii w Lublinie

A-V malformations

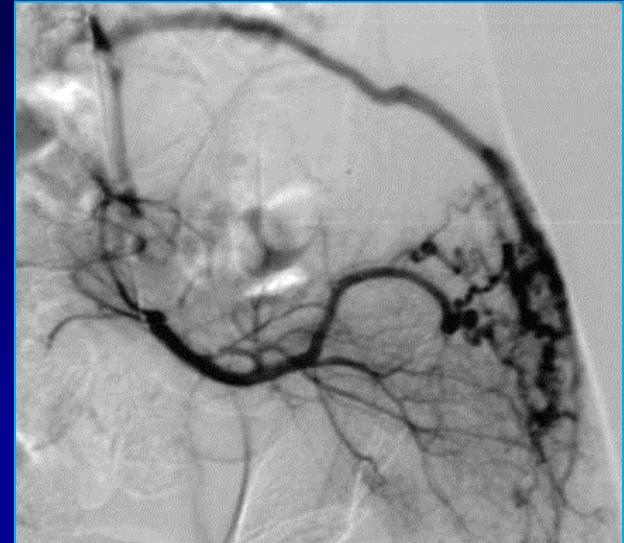
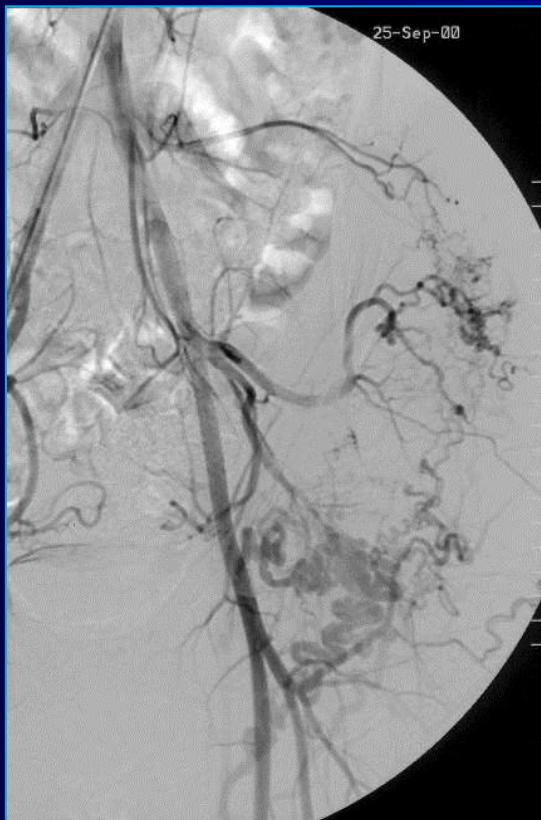
localized & diffuse



Hudge a-v malformation

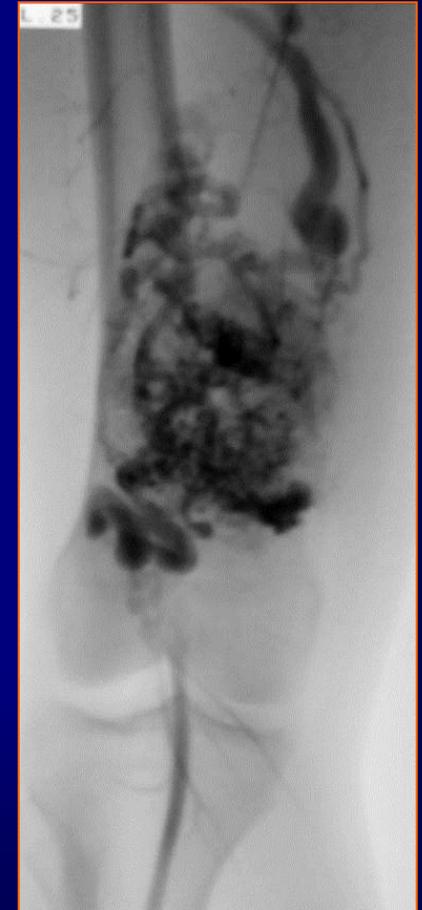
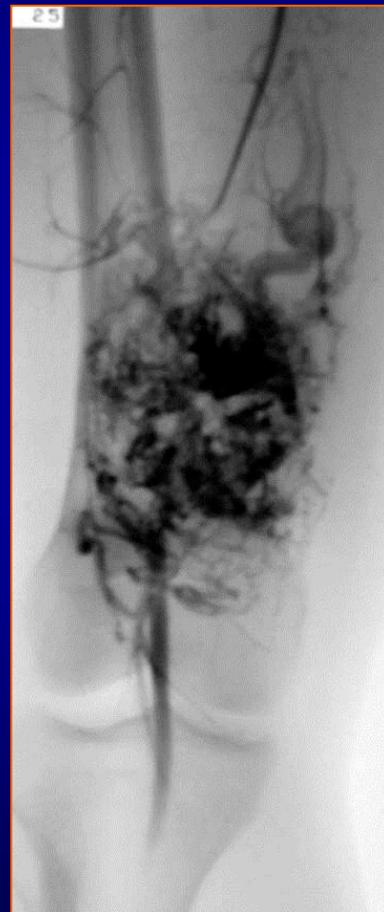
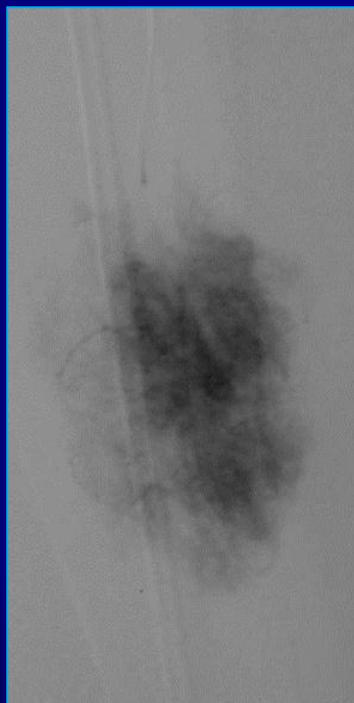
in pelvic / gluteal area

macrofistulous & microfistulous



Vascular malformation or hypervascularized tumour ?

histopathology is needed !!!



IV. Hypervasculatized tumors

examples

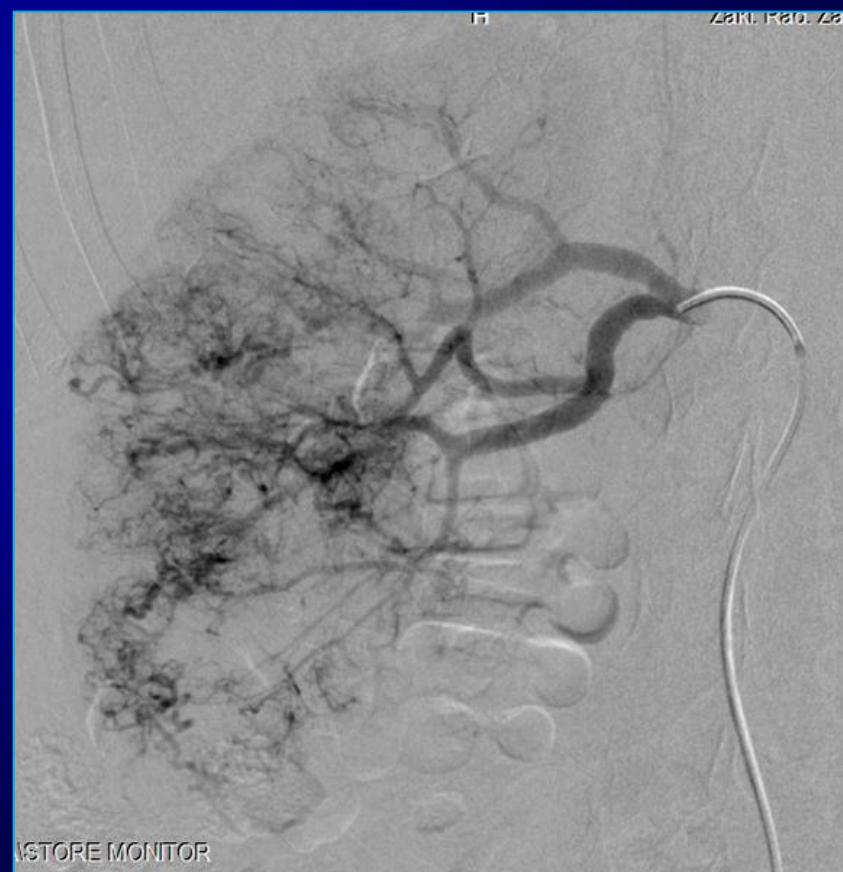
- Pathologic vessels:
 - multiple & tortuous
 - arterial broadening / aneurysms
 - a-v fistulas
 - venous dilations
- Both – malignant & benign tumours can be hypervasculatized



Renal cell carcinoma

RCC

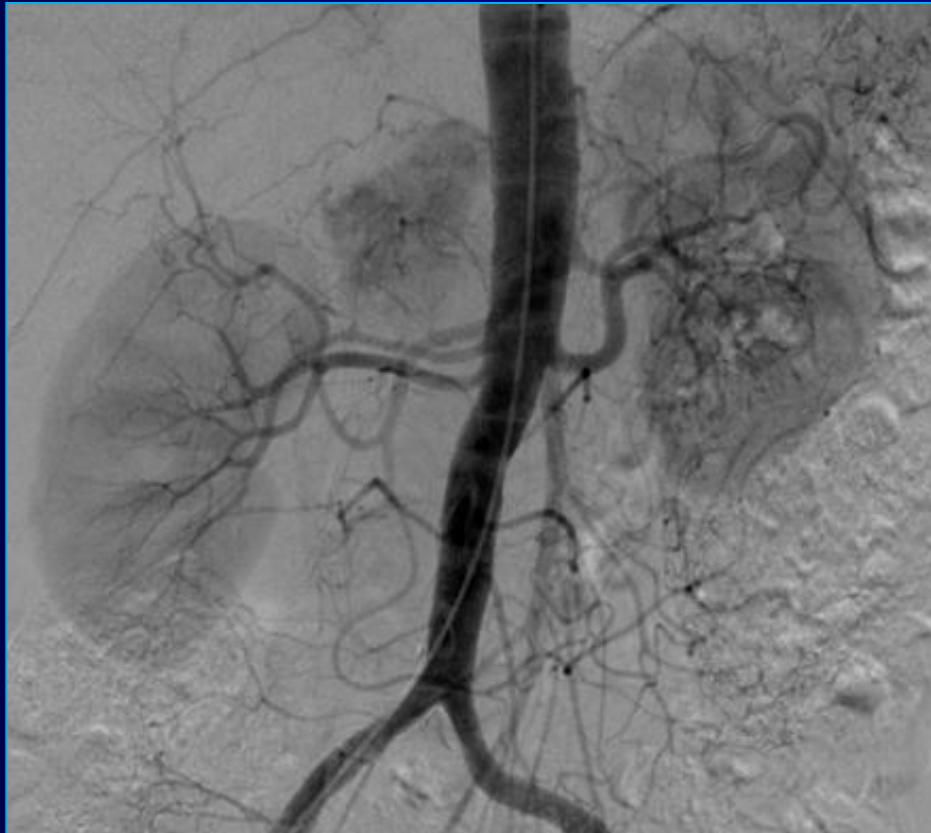
malignant & hypervascularized



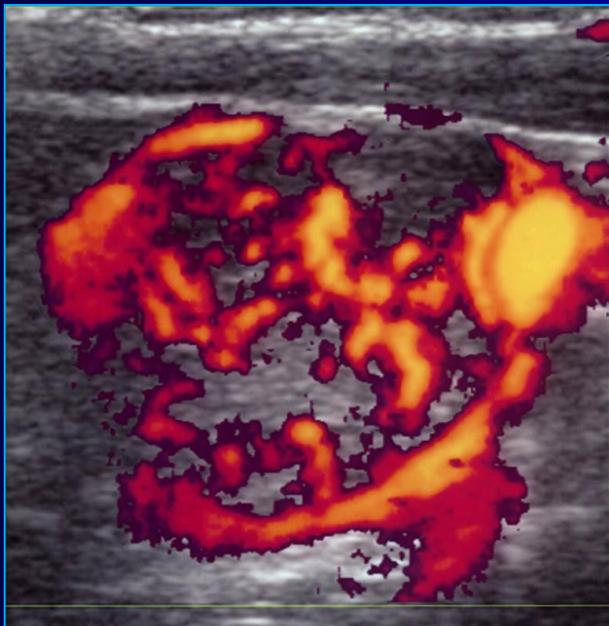
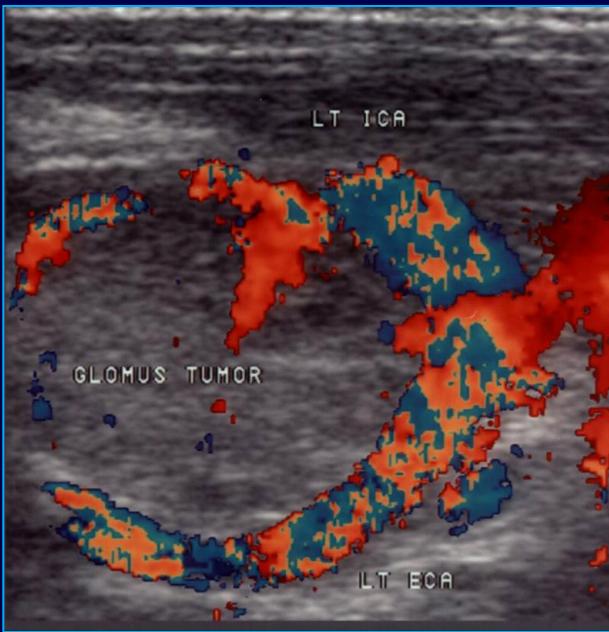
Suprarenal / adrenal adenoma

benign but with hormonal activity

most of endocrine tumours are hypervascularized

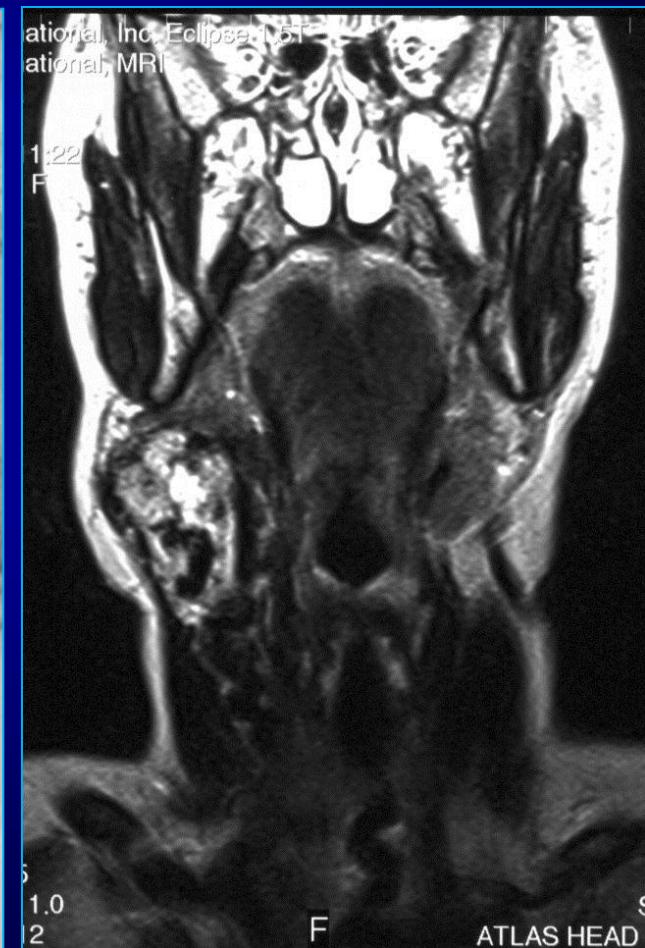


A STORE MONITOR



Paraganglioma

wine glass tumour (*glomus tumor caroticum*)



Mesenchymal tumours

malignant sarcomas & benign: fibromas / myomas / etc.

are usually hypervascularized

