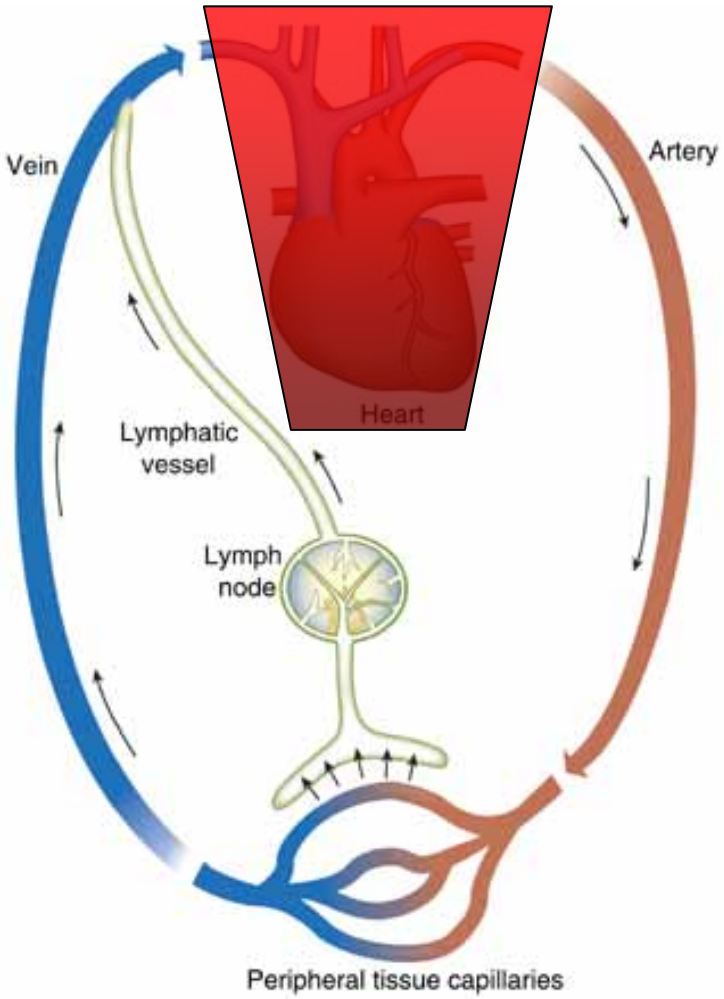
Ultrasound in Vascular Surgery

Torbjørn Dahl

The field of vascular surgery

Veins – dilatation and obstruction (varicose veins and valve dysfunction)



Arteries – dilatation and narrowing (aneurysms and atherosclerosis)

Use of ultrasound in vascular surgery

- Diagnostic purposes
- Therapeutic purposes
- Perioperative control
- Surveillance after surgery

Ultrasound equipment

- Linear and curved linear probes in the range of 2 – 15 MHz
- Multifrequency probes
- Transportable and portable machines

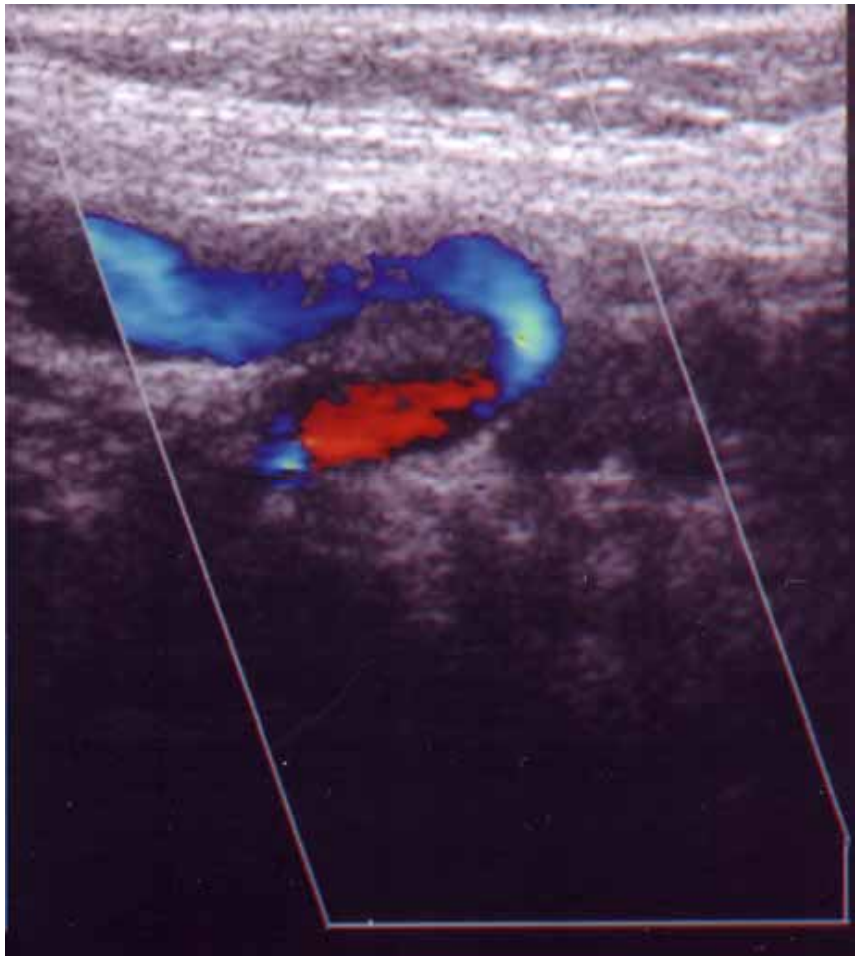
How is the ultrasound service organized?

- Department of Radiology
- Vascular laboratories (mostly abroad)
- Clinicians in fields of interest (gynecology, cardiology, vascular surgery)

How could ultrasound be easier to use?

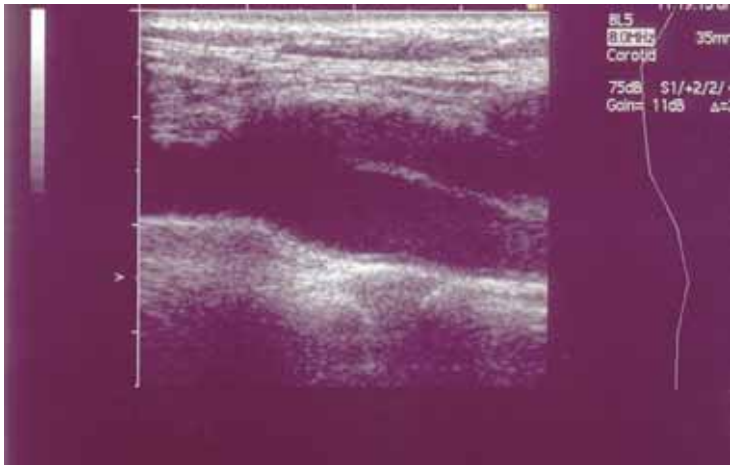
- Improved user interface
- Less buttons – ”nothing is too simple for doctors”
- Image quality

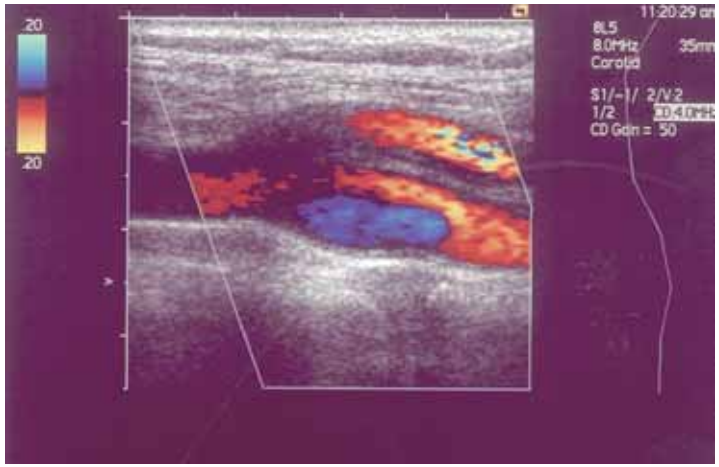
Limitations of vessel visualization



- Anatomy
- Tortuous vessel
- Heavy calcification
- Gas (bowel, lungs)

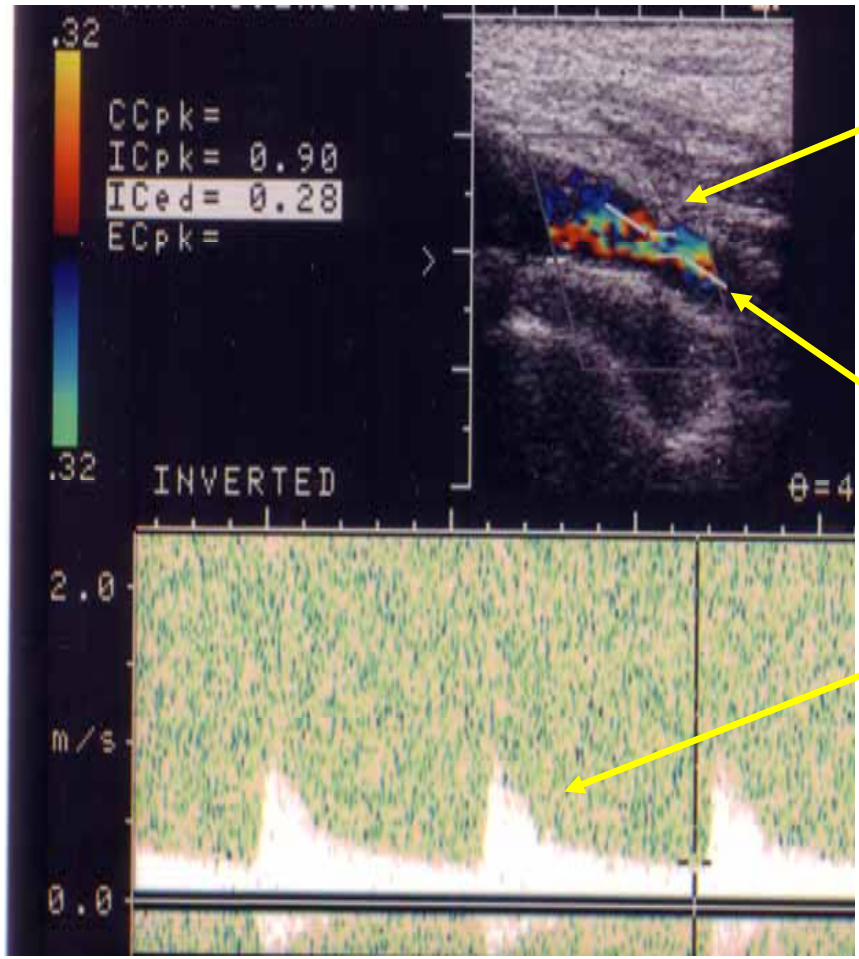
What kind of ultrasound?





- B-mode for tissue imaging
- Colour flow for vessel identification
- Velocity doppler for grading of stenosis
- Contrast agents to enhance image quality

Doppler Ultrasonography (”triplex US) of the Carotid Artery



- Colour doppler indicates direction of flow and turbulence
- Angle corrected doppler for velocity measurements
- Spectral doppler indicating blood flow velocity profile

Velocities for grading of stenosis

Table after Rutherford, p. 1779

Stenosis in %	< 50	50-79	80-99	Occlusion
Velcocity PSV_{ICA}	<125 cm/sec	>125 cm/sec	>125 cm/sec	No flow*
Velocity EDV_{ICA}		<140 cm/sec	>140 cm/sec	

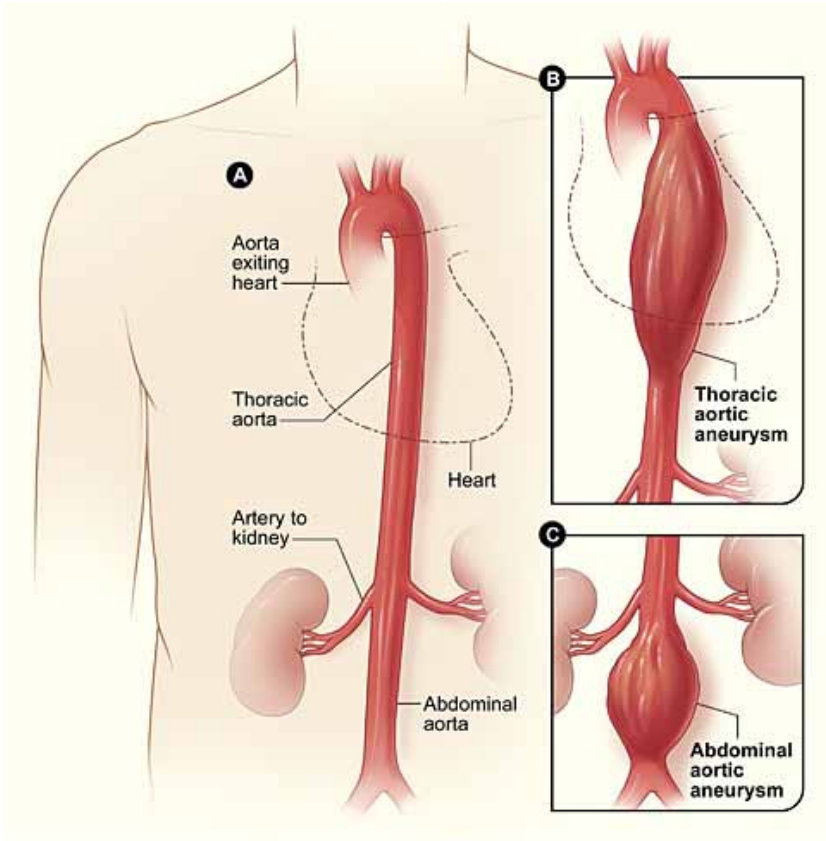
*Additional features like high resistance pattern in the CCA with low or zero EDV, reversal of flow in the bulb area, increase in contralateral flow

Clinical problems in vascular surgery

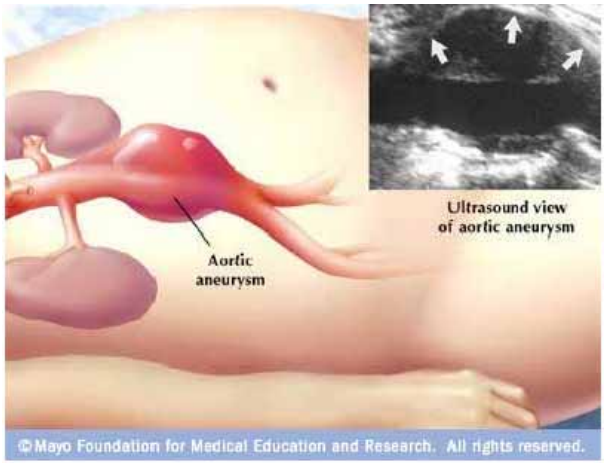
Abdominal aortic aneurysms

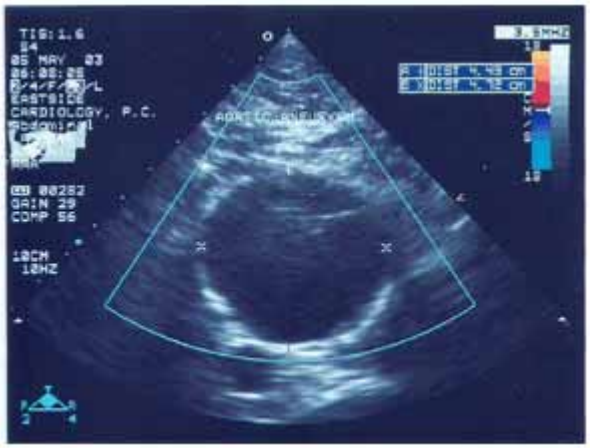
What is an aneurysm?

- Segmental dilatation of an artery twice the size of the normal adjacent artery
- Mainly seen in aorta, iliac arteries and the popliteal artery



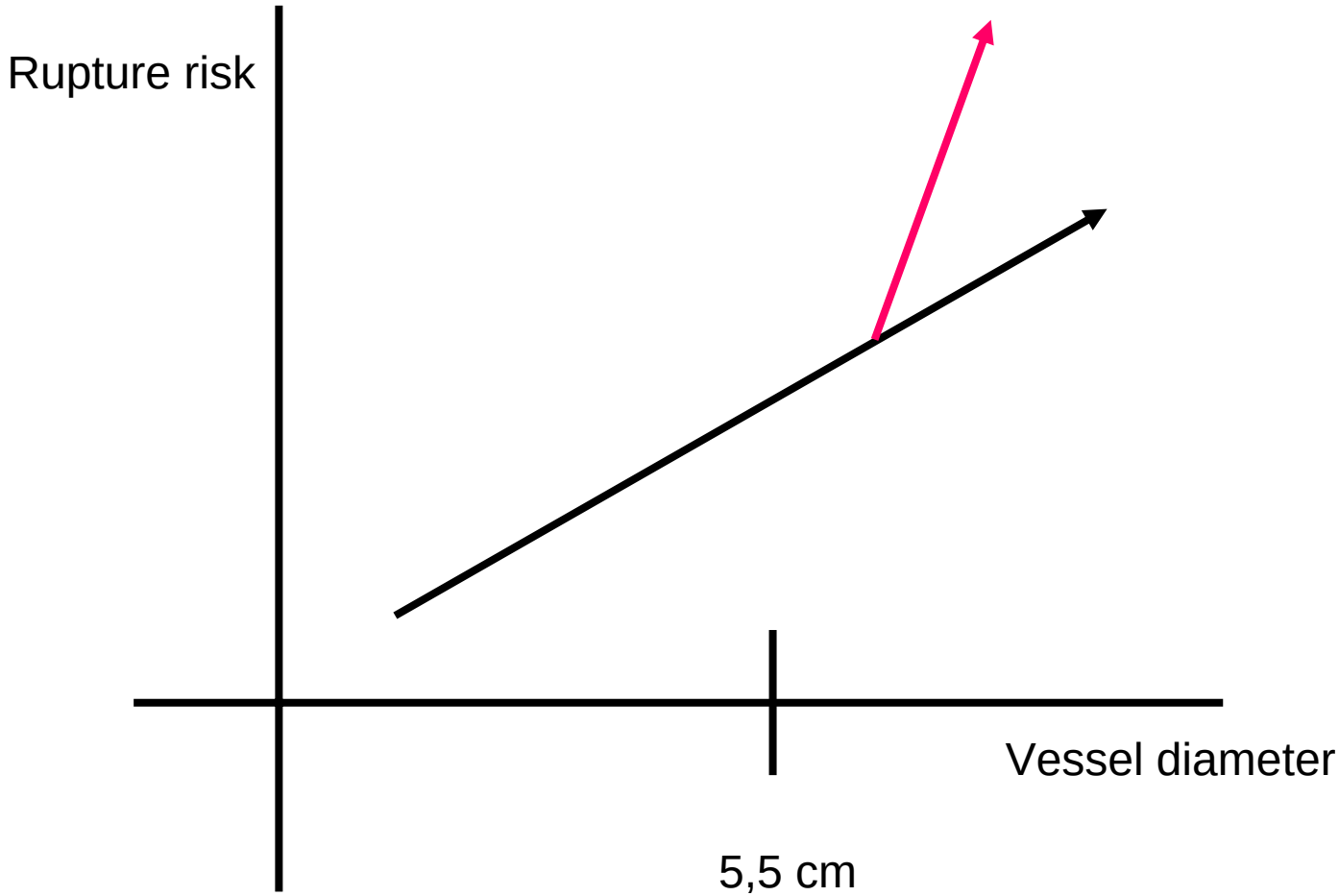
Abdominal aortic aneurysm(AAA)



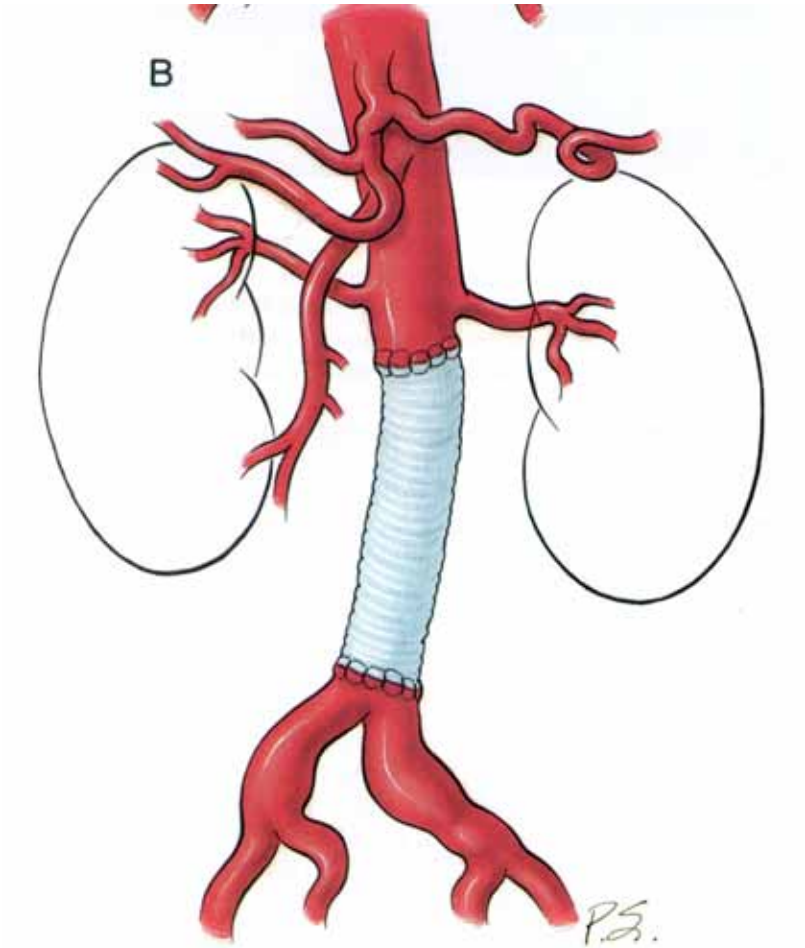


- Easily visualized by ultrasound
- Growth is monitored
- Planned operation when AAA reaches 5,5 cm in diameter
- Rupture can be lethal

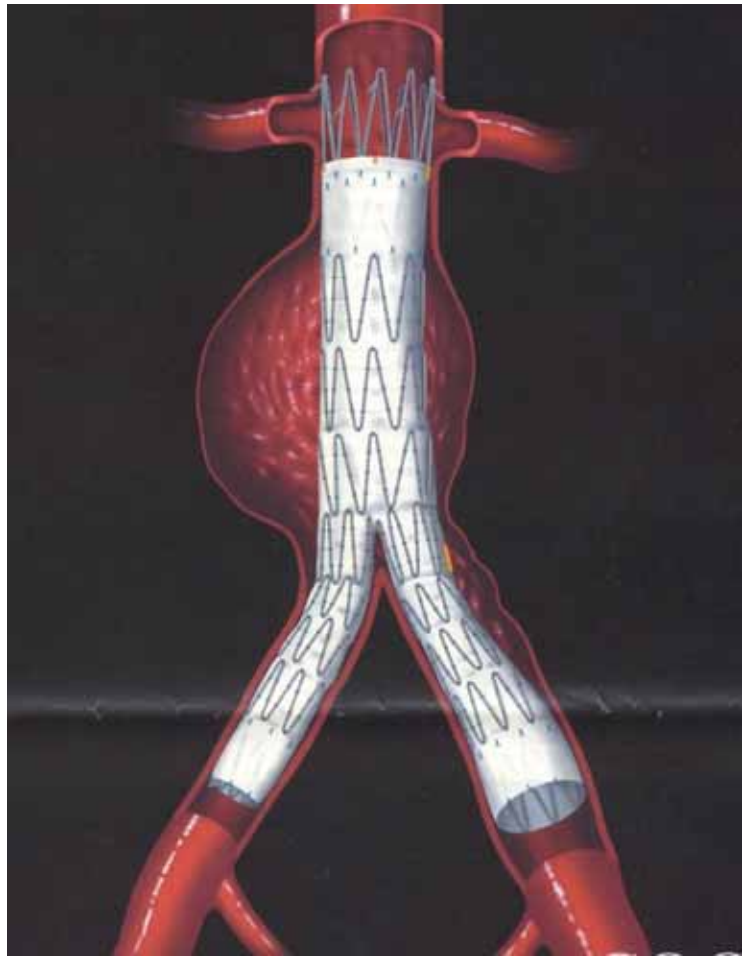
Aneurysm growth and rupture risk



Surgical treatment

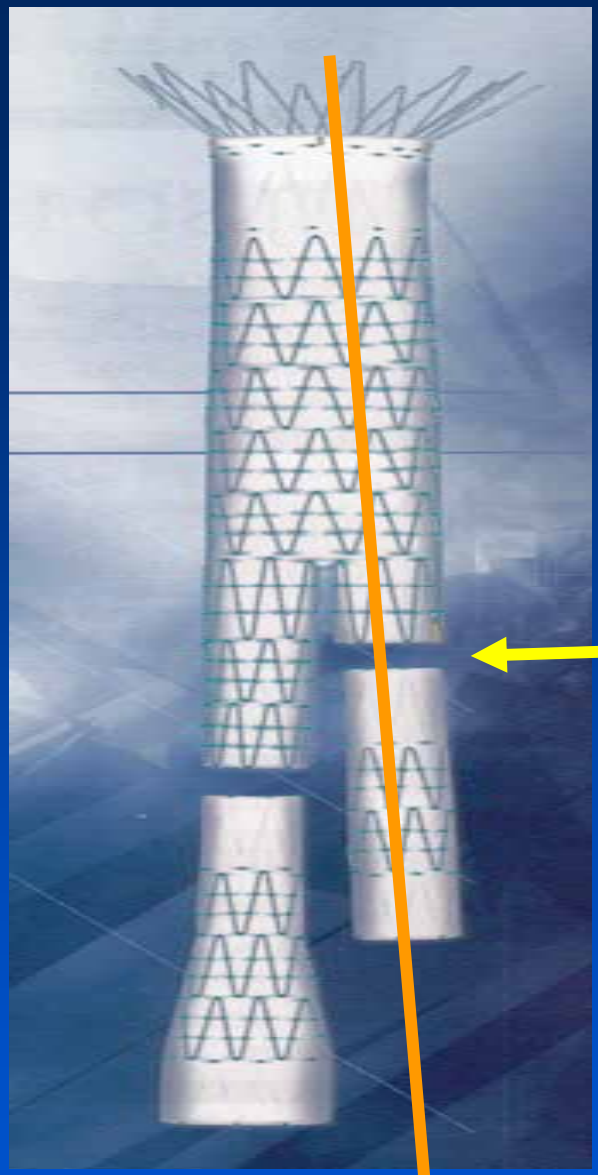


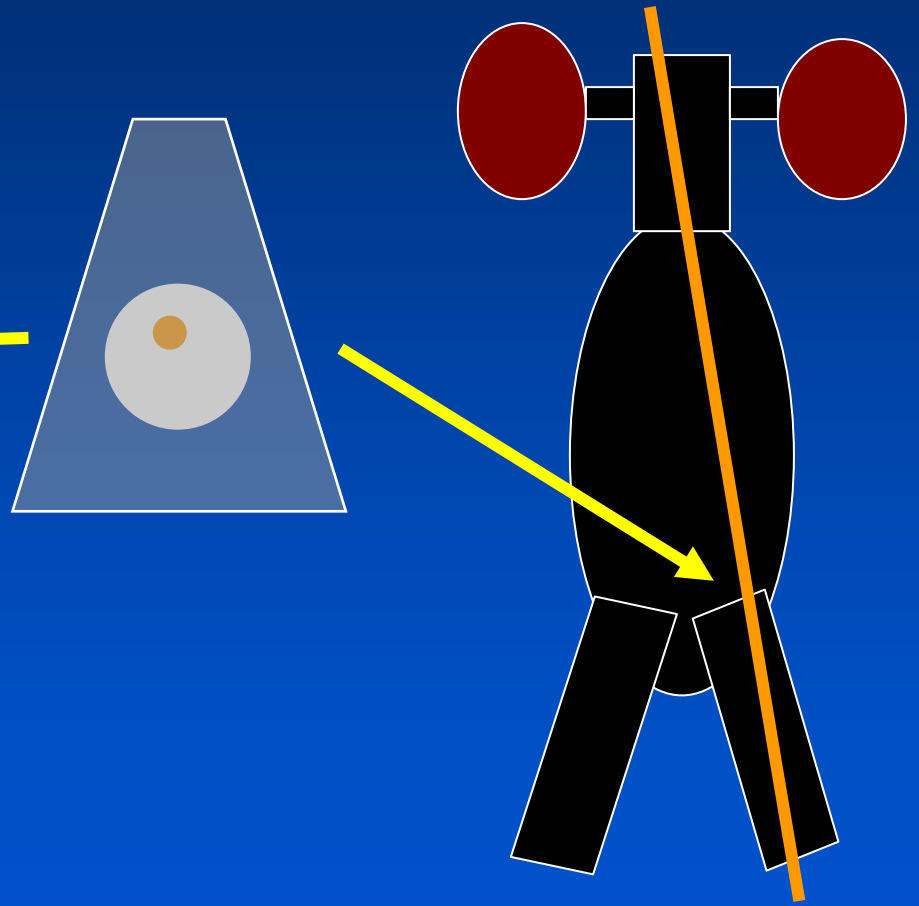
Open repair



Endovascular repair

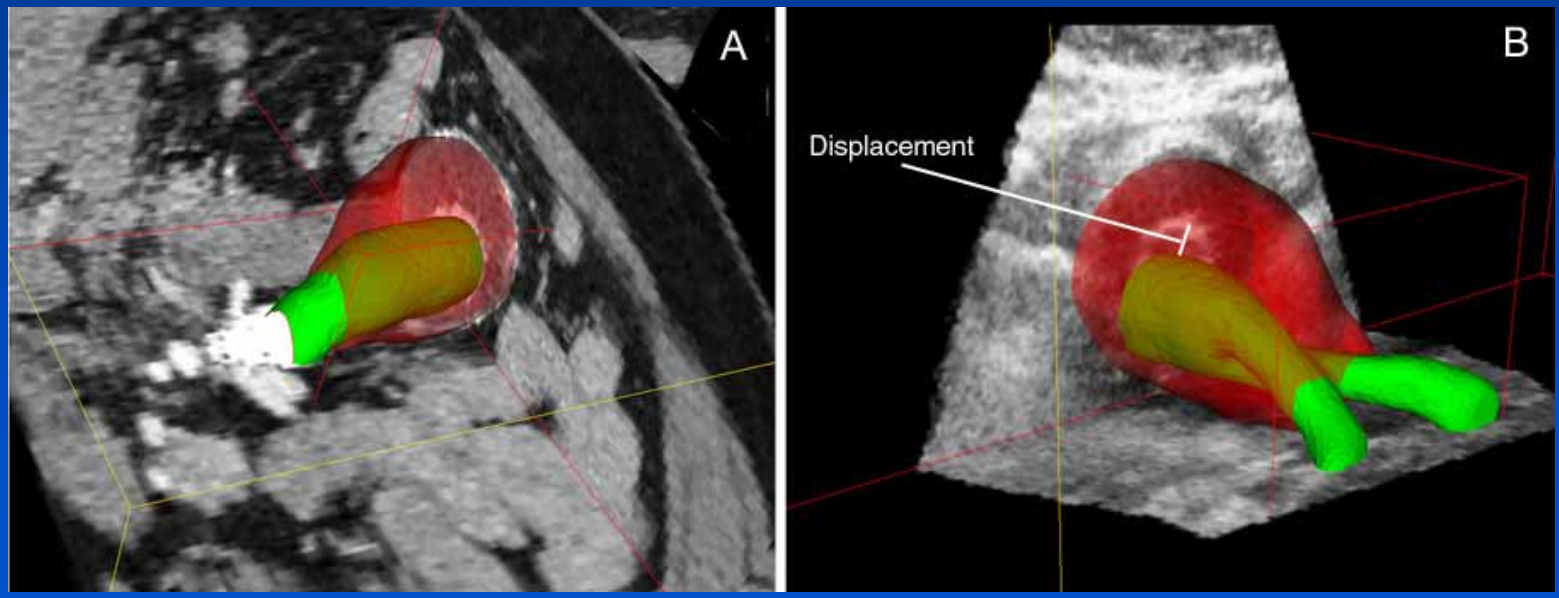
Guide wire for second-limb prosthesis in EVAR



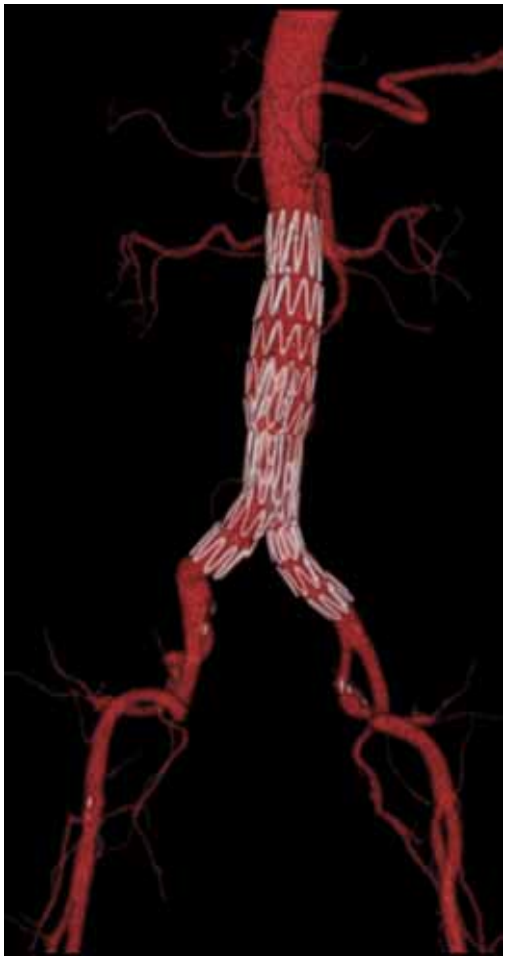


Multimodal imaging

- Preoperative planning in complicated anatomy
- CT/MRI/US in the same scene
- Intraoperative navigation



Endovascular repair is currently monitored by annual CT

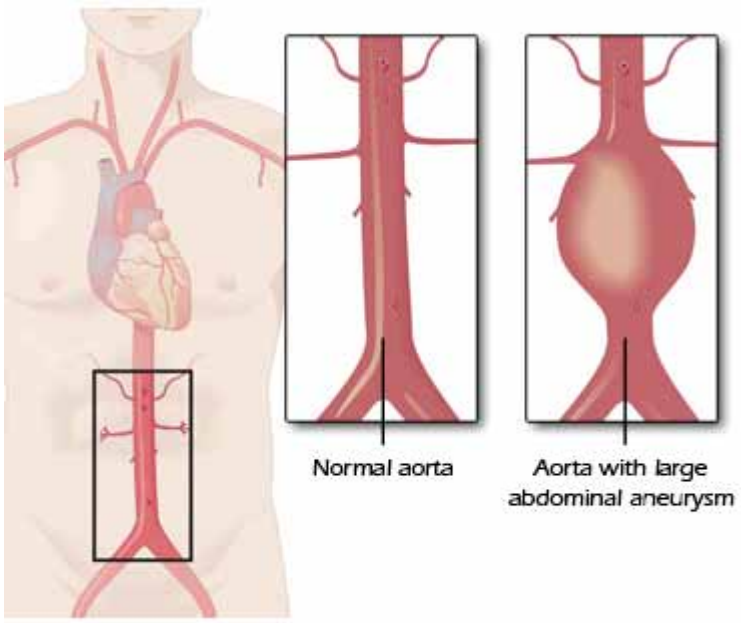


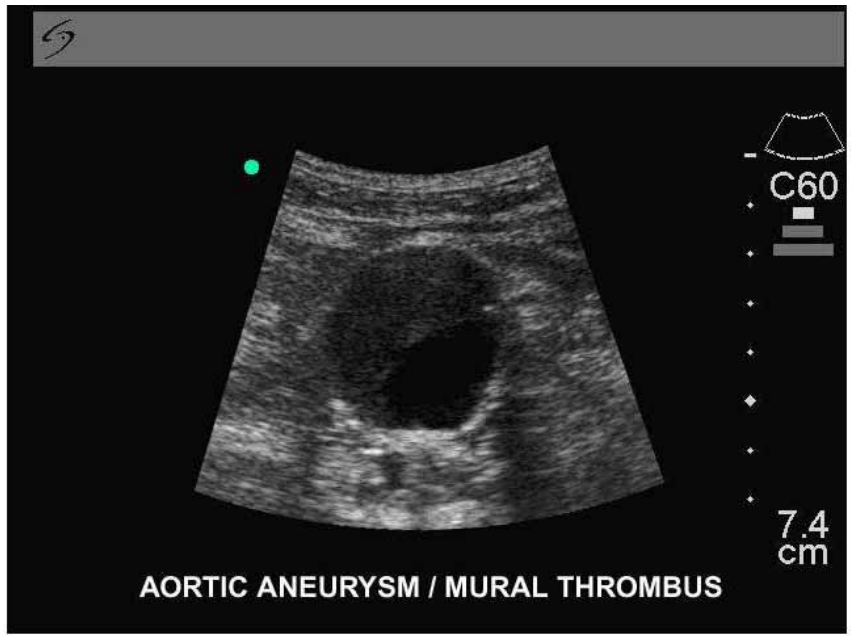
- Ultrasound could replace CT, providing:
- Aneurysm diameter
- Leakage into the aneurysm sac

Could we identify and treat the aneurysms at risk for rupture?

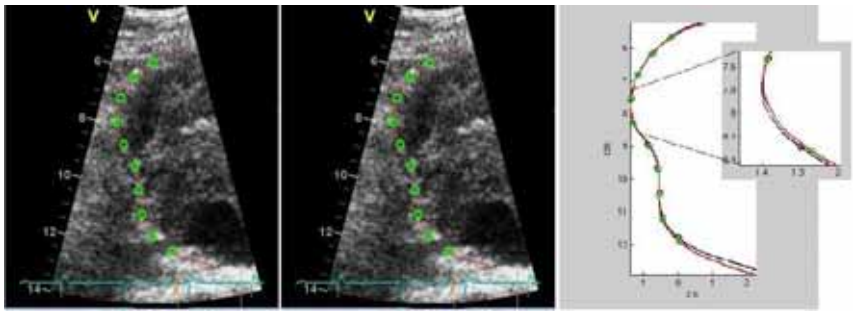
Analysis of aortic vessel wall motion

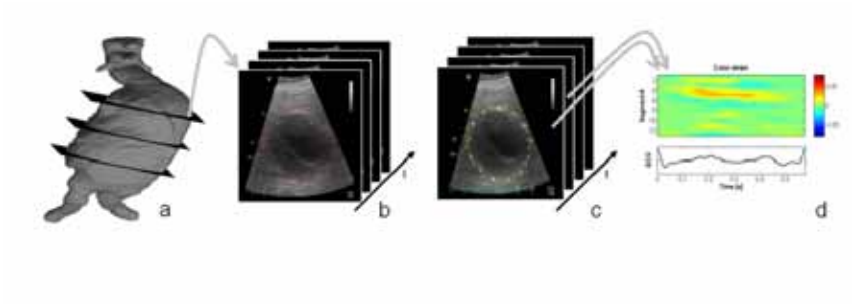
Cyclic stress of the aortic wall

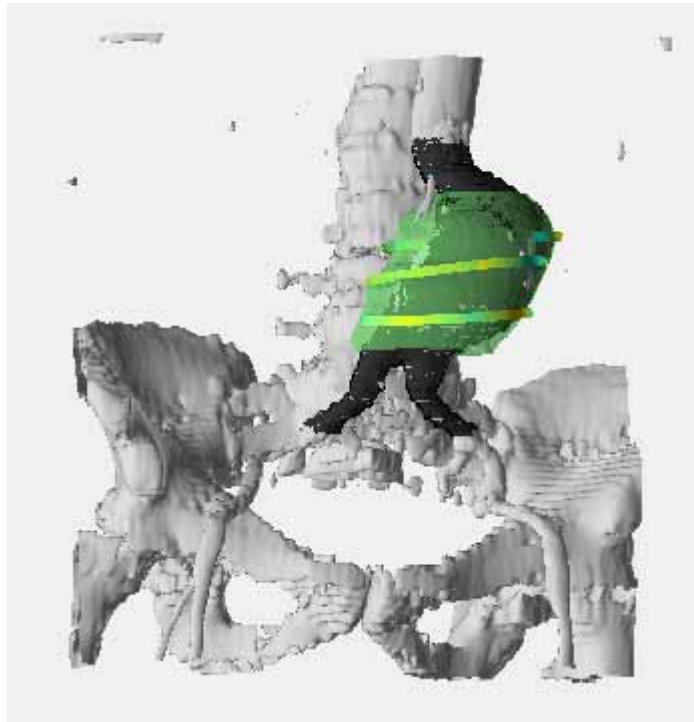




Strain in the aortic wall

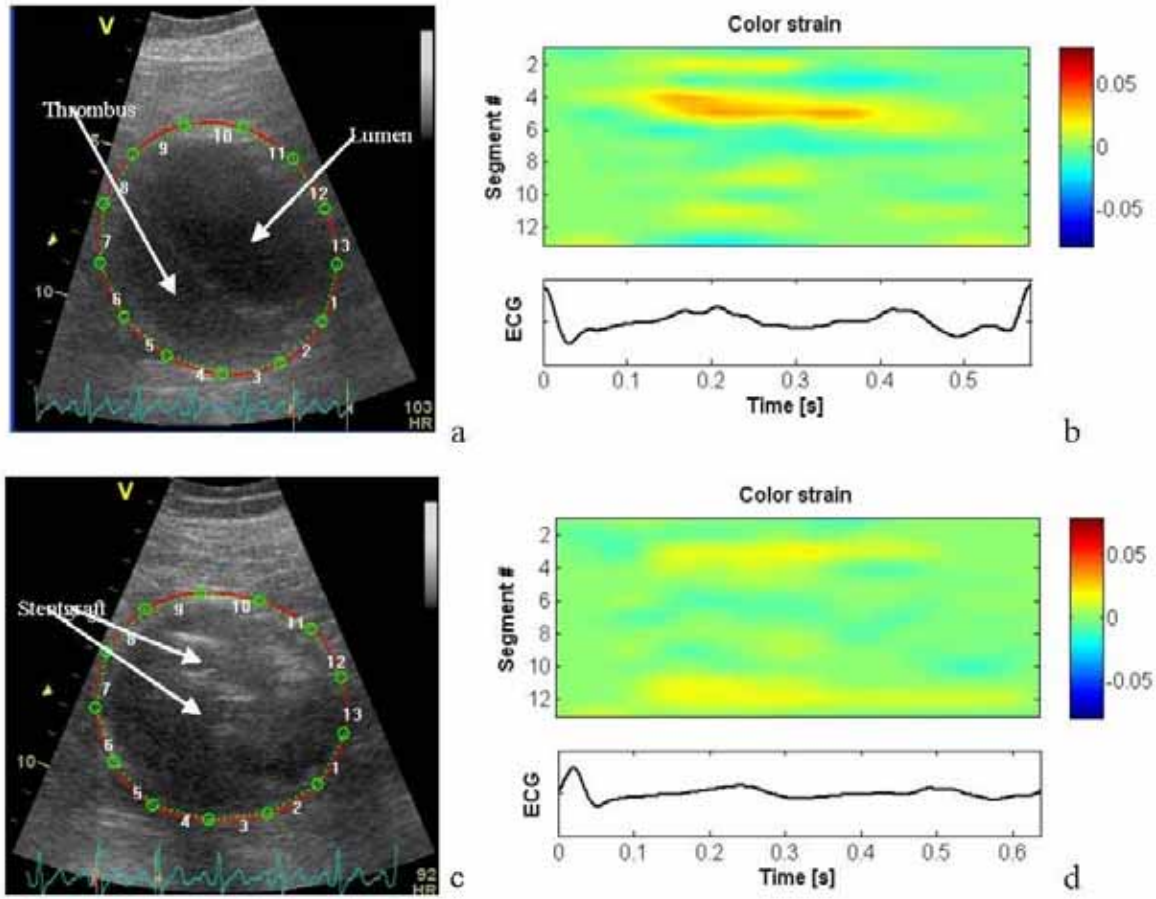






Courtesy of R. Brekken SINTEF Health

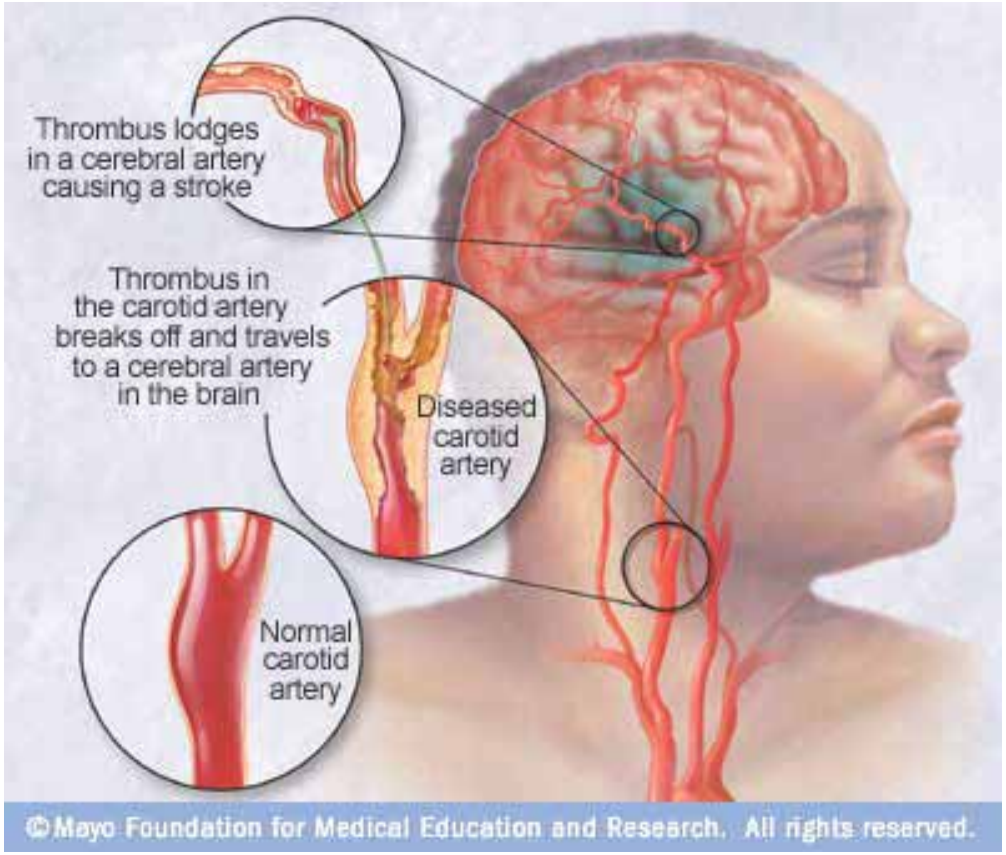
Reduced strain after EVAR



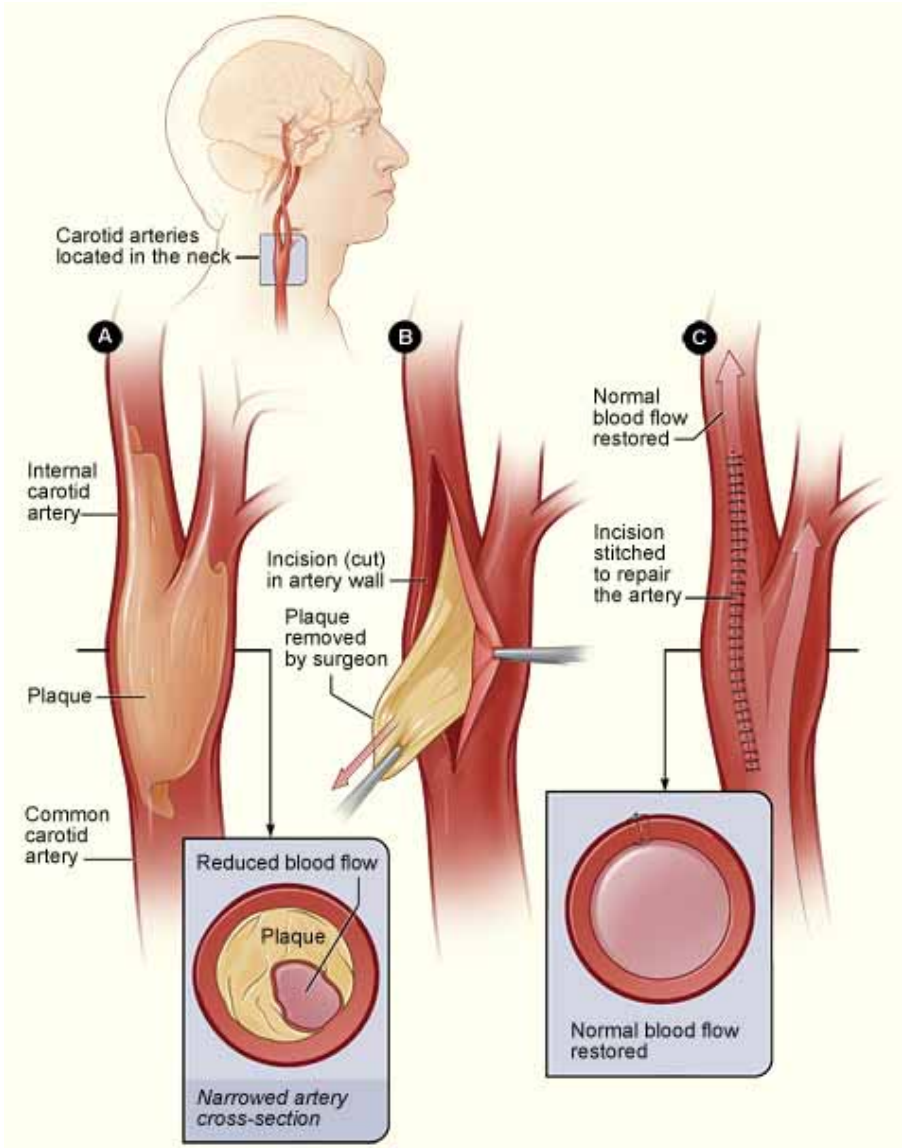
Narrowing (stenosis) of the carotid artery

What is the cause of stroke?

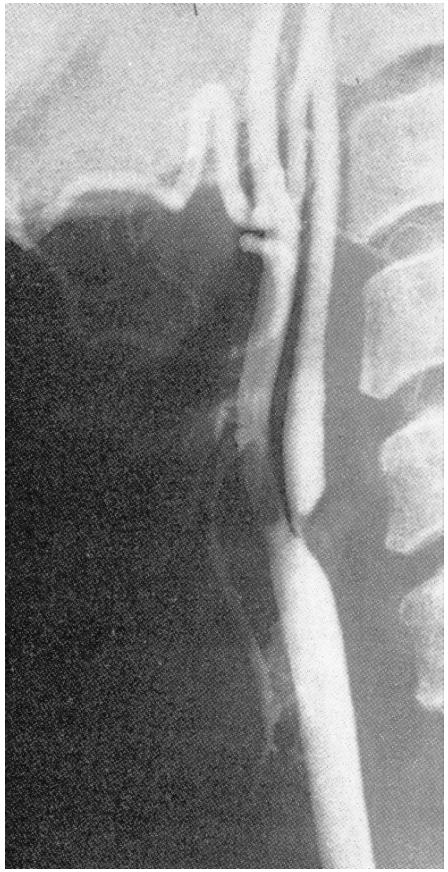
- Thromboembolic cause in 80% of the cases – the origin ef emboli could be precrebral vessels in 20% of the patients



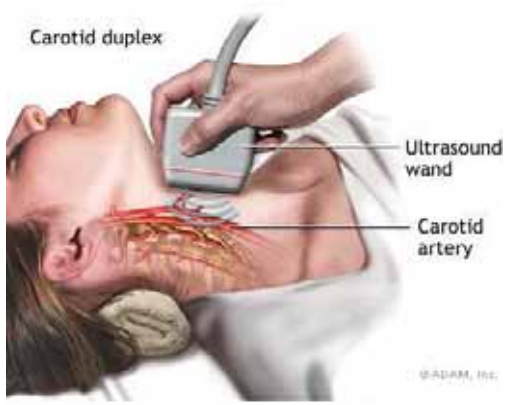
Surgical treatment of carotid artery stenosis

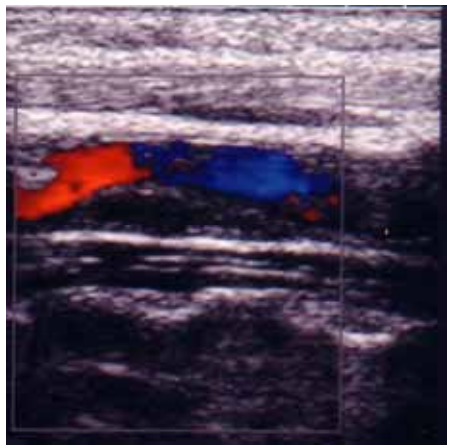


How is a carotid artery stenosis detected?



DSA angiography





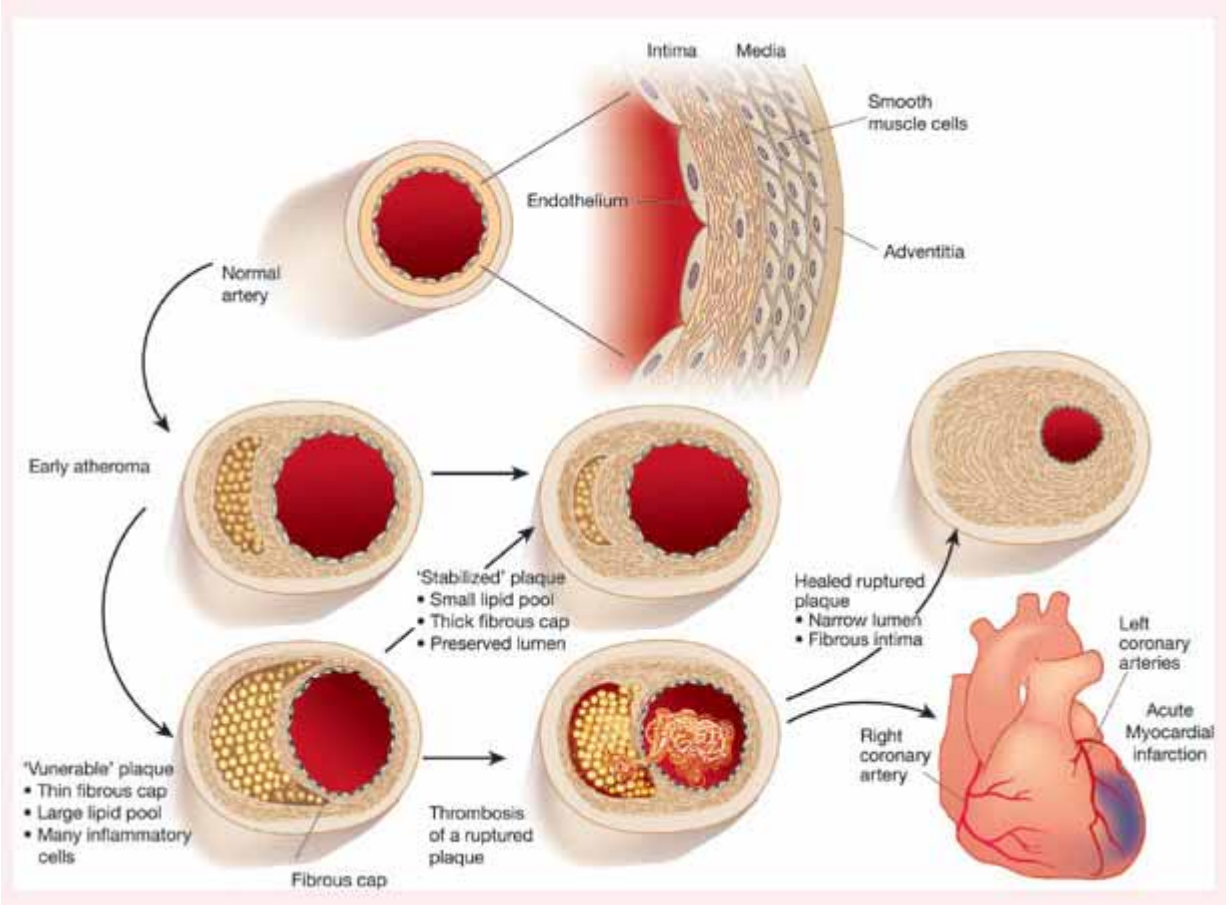
Ultrasound

MRI

What are the objectives of carotid plaque imaging?

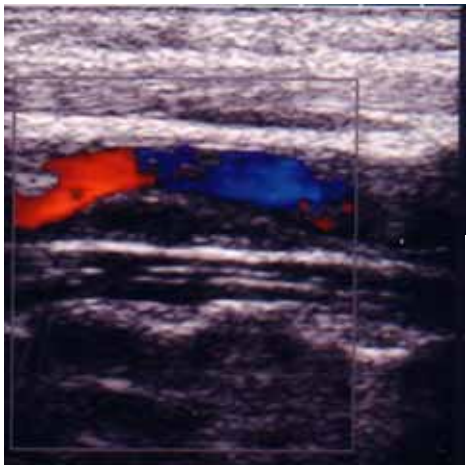
- To assess the degree of stenosis
- To assess the risk of embolization
- To suggest the right intervention

Plaque development – a dynamic process

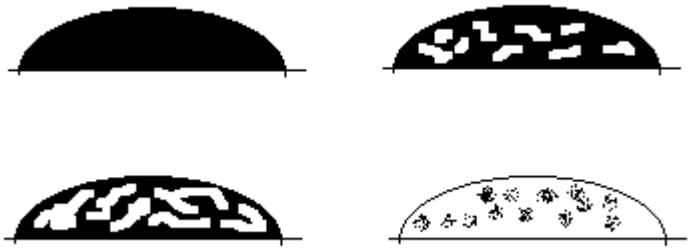


Nature 2002

Carotid plaque appearance

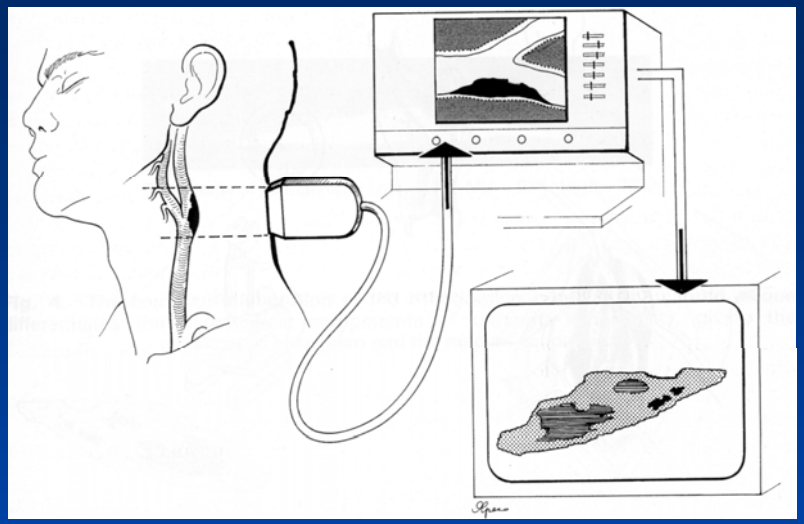


- Echogenic – calcified
- Echolucent – lipid-rich
- Visual scale
- Digital scale (GSM)

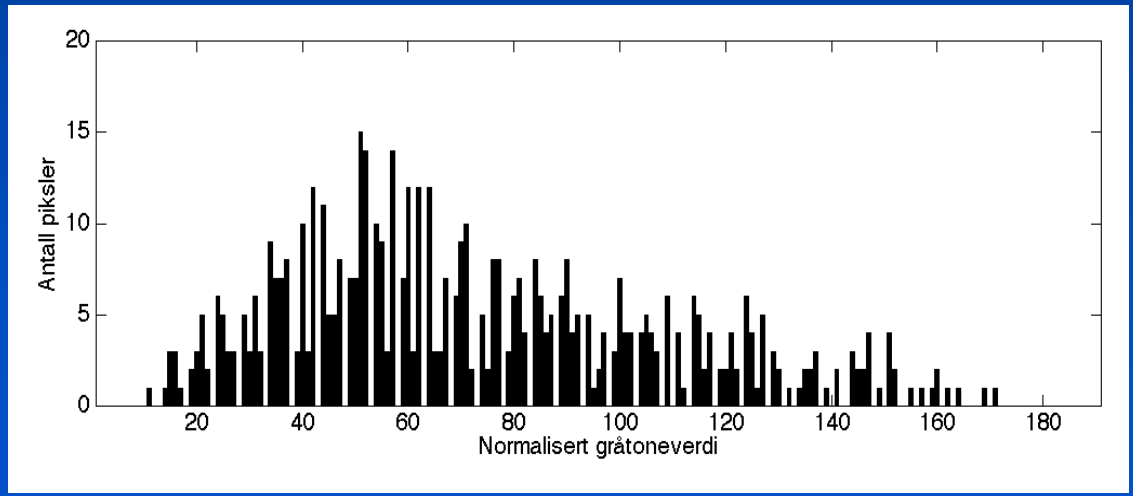


Gray-Weale´s classification from 1-4

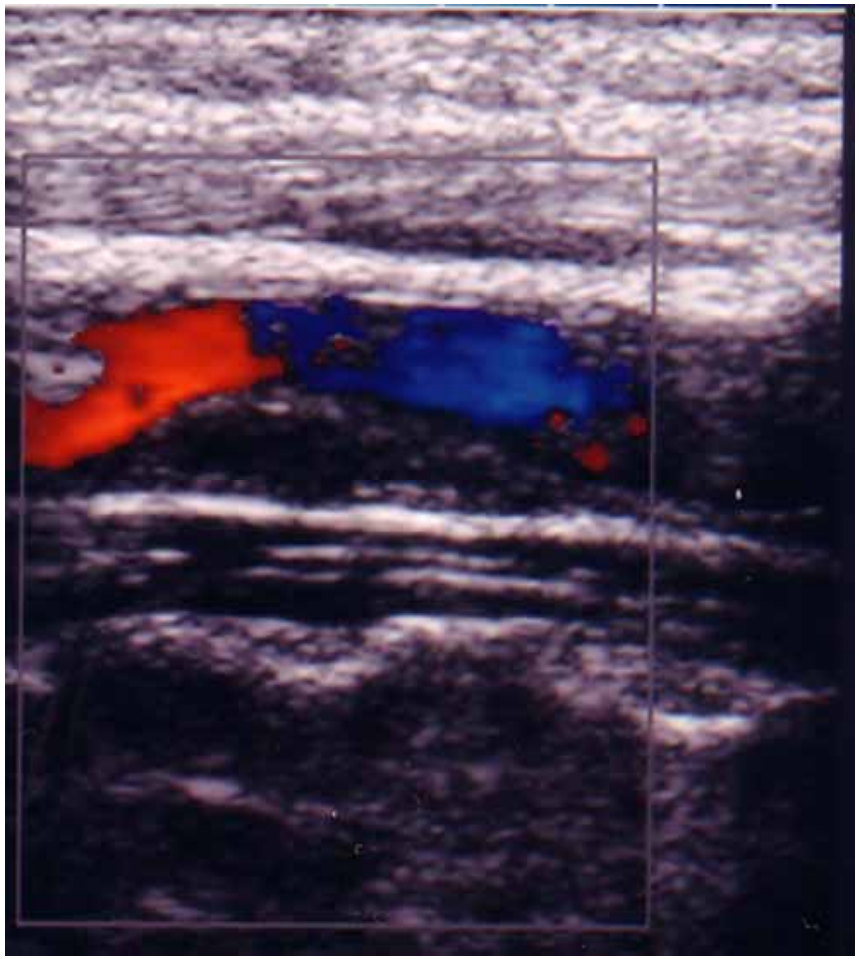
Gray-scale analysis of carotid artery plaque



Gray scale median – low values for soft plaques

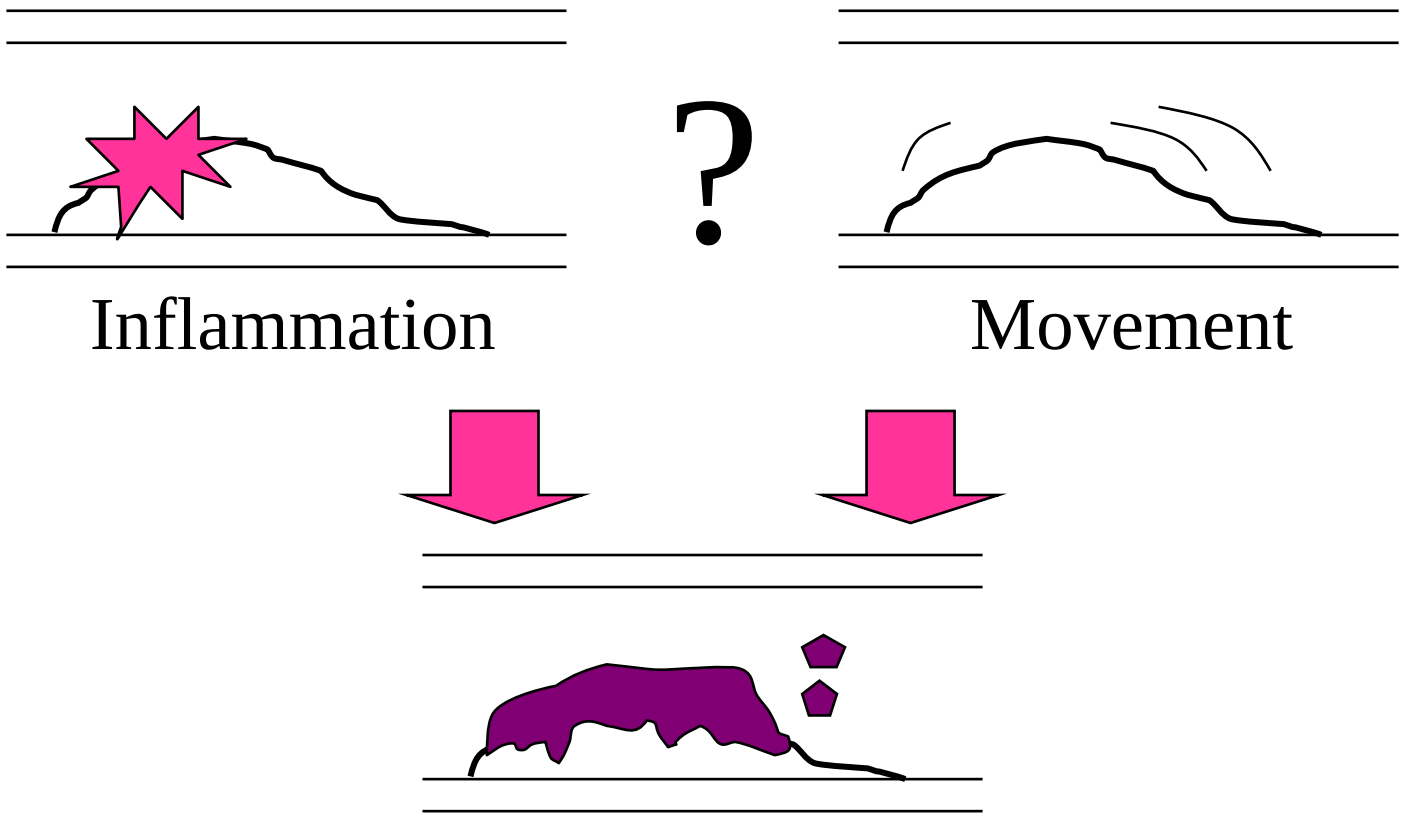


Soft plaque

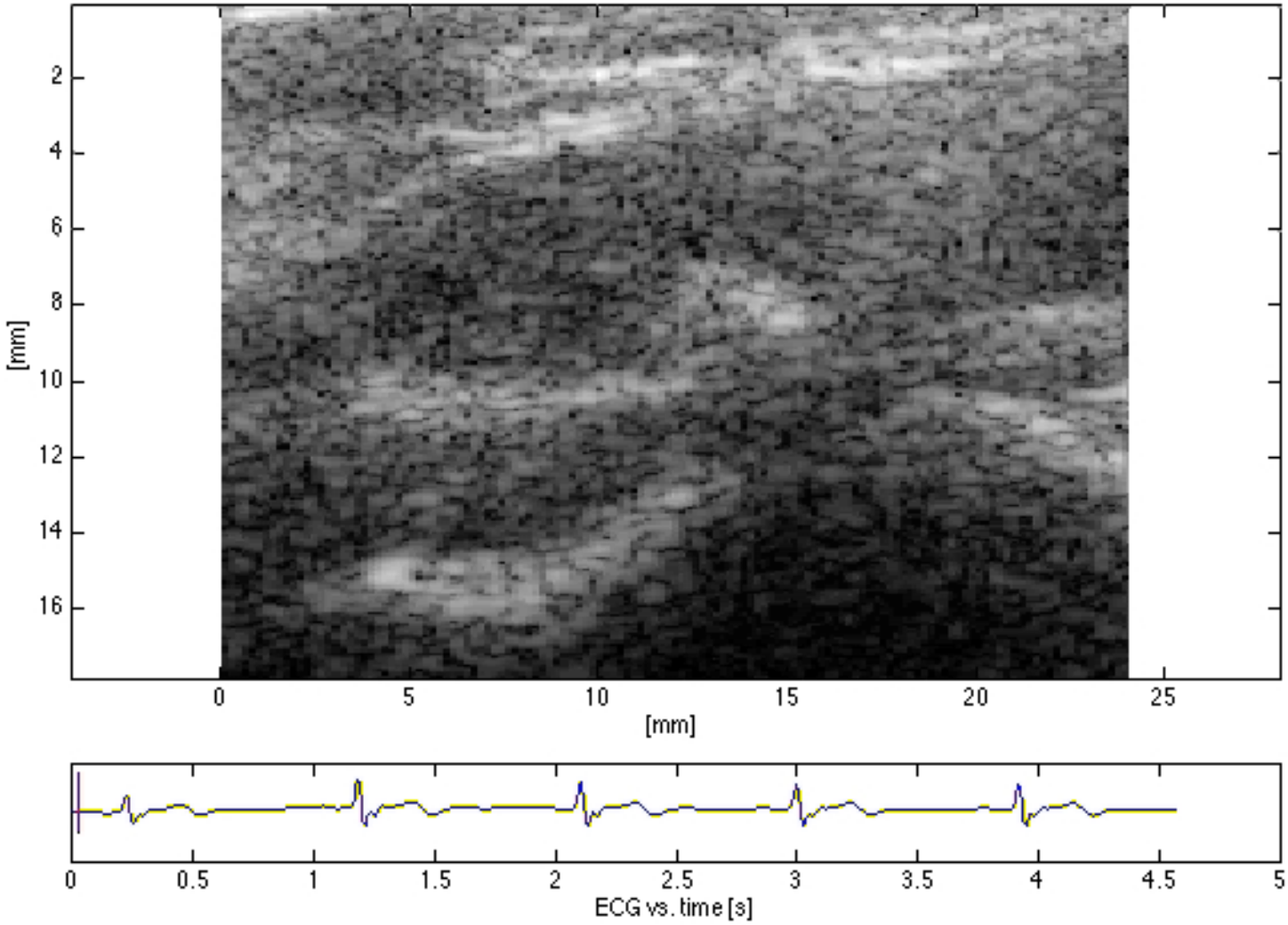


- Overall increased risk for stroke (Mathiesen)
- Increased stroke risk in symptomatic patients unfit for surgery (Grønholdt)
- No hard evidence as an indication for CEA in asymptomatic patients yet

Possible triggers of plaque rupture and embolization

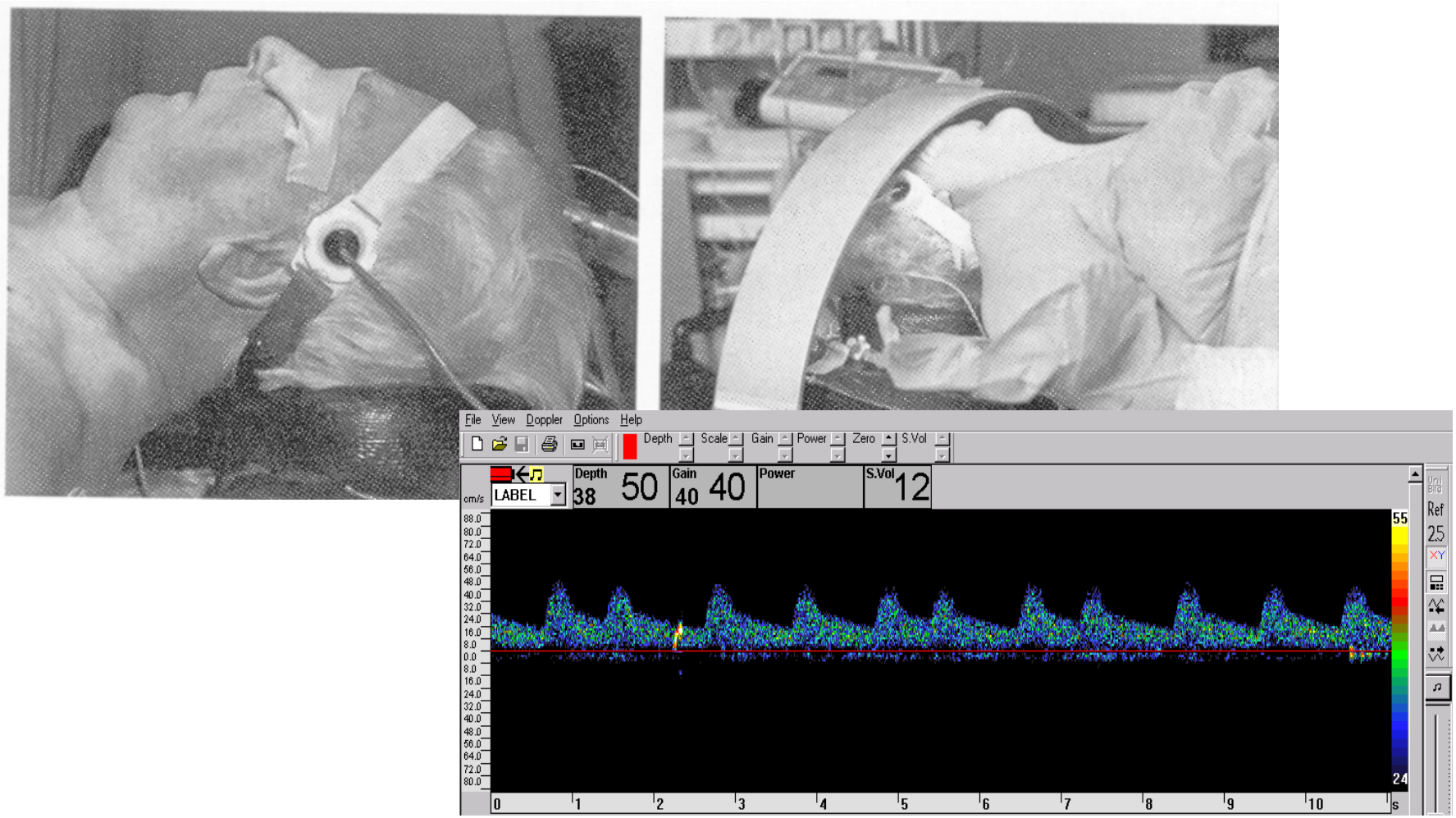


Longitudinal image (24 fps = 2/3 of actual speed)



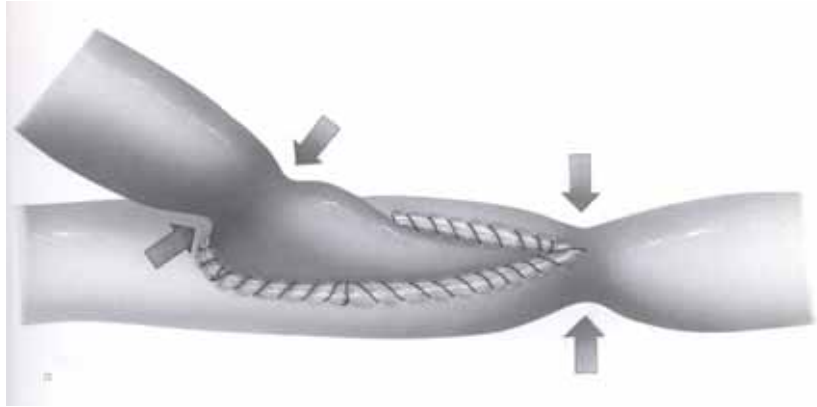
Perioperative control

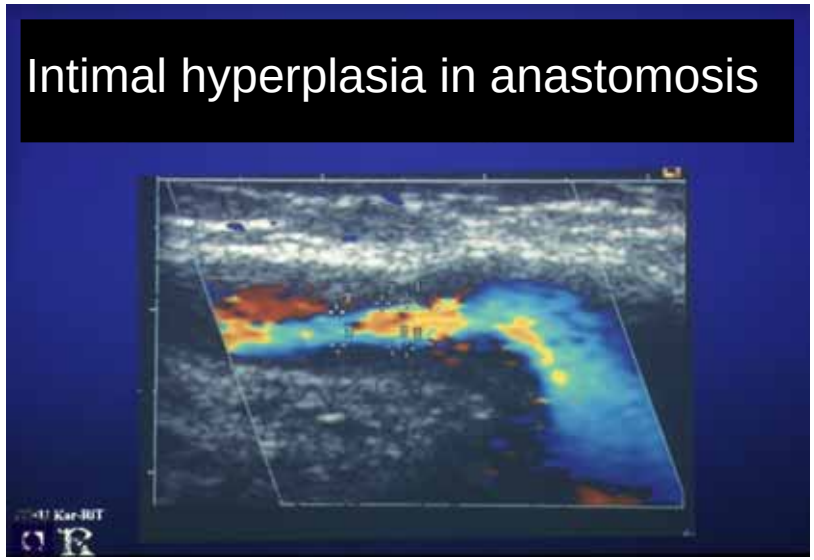
Transcranial ultrasound to detect peroperative emboli



Postoperative occlusion of bypass

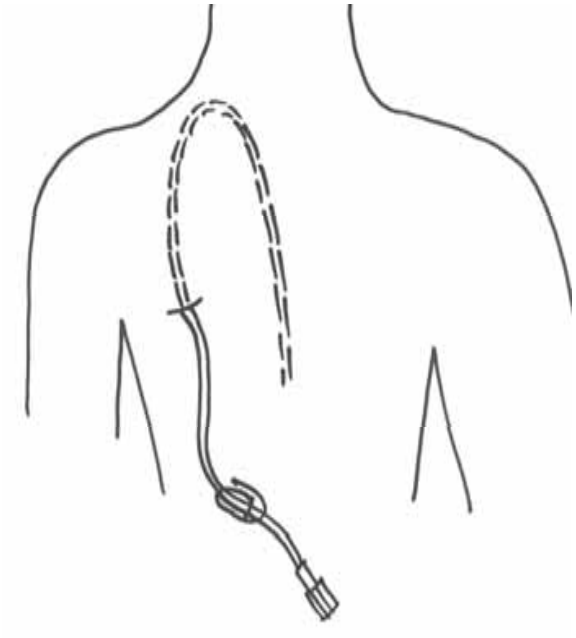
- Early postoperative phase – technical error or intimal injury
- After months – excessive scar tissue or occlusion by thrombosis
- After years – progression of underlying disease



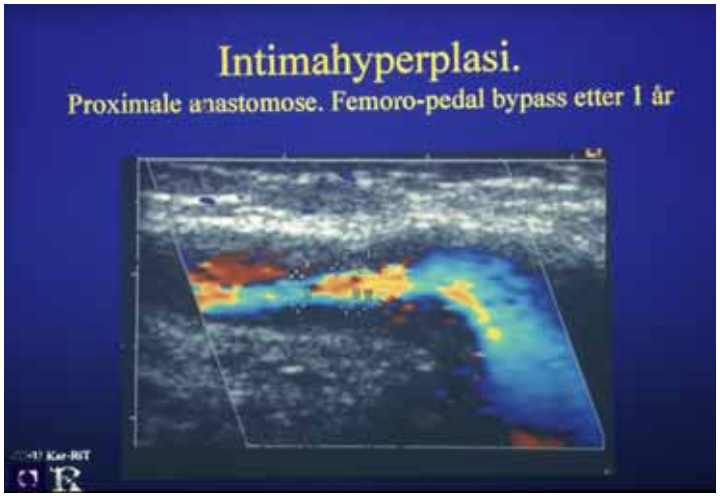


Venous access for medication or dialysis

- To place a central venous line or port
- To visualize arteries and veins



Surveillance and follow-up after surgery

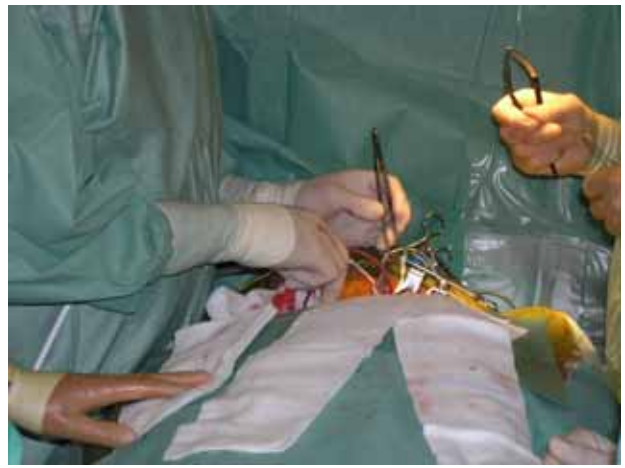


- Ensure patency of bypass grafts
- Detect and treat restenosis
- Follow-up of arteriovenous fistula for dialysis

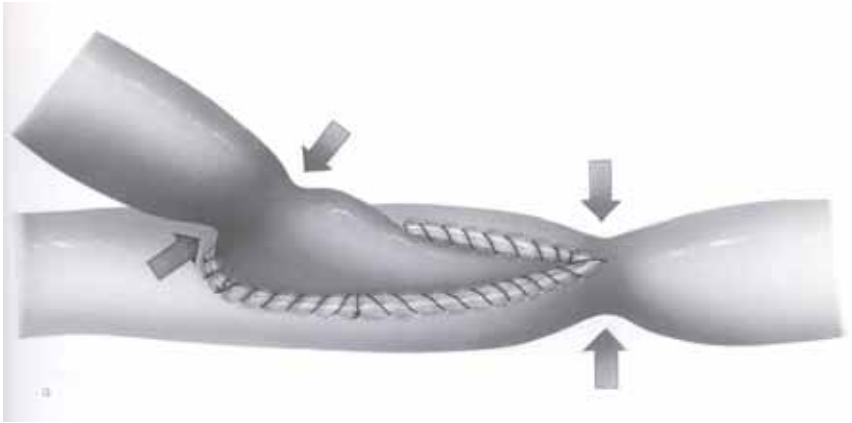
Ultrasound in the operating room

Perioperative control and anatomical visualization

Limited space in the OR

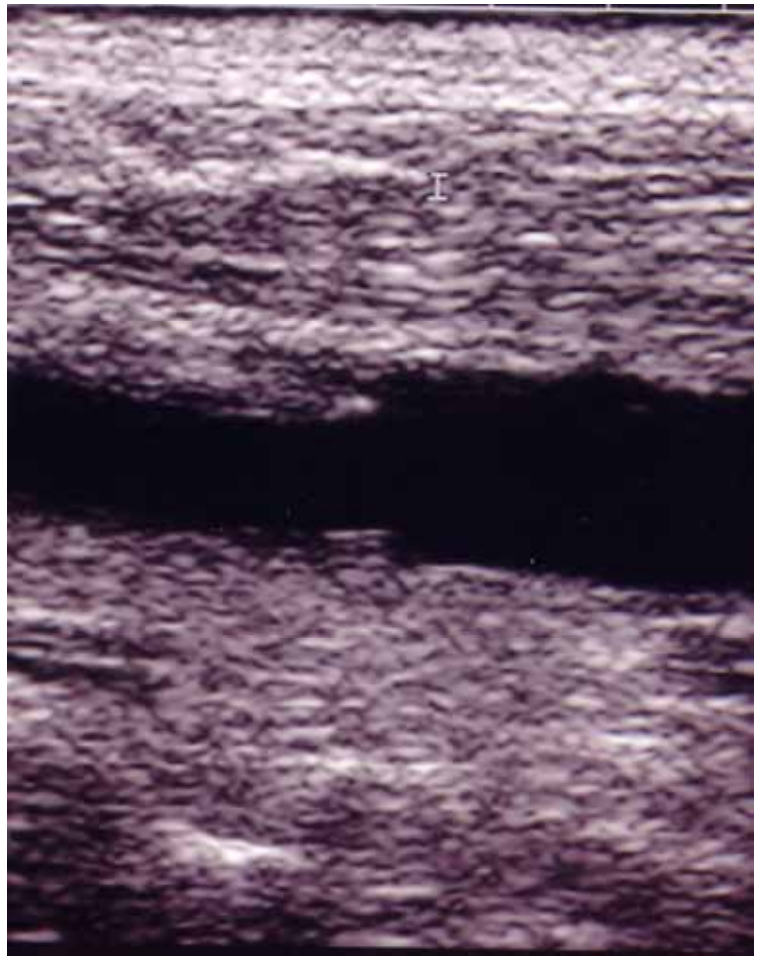


Perioperative ultrasound



- Quality control of reconstruction
- Anatomical and functional view
- Surgical guidance during reoperations
- Operator dependent
- Probe requirements

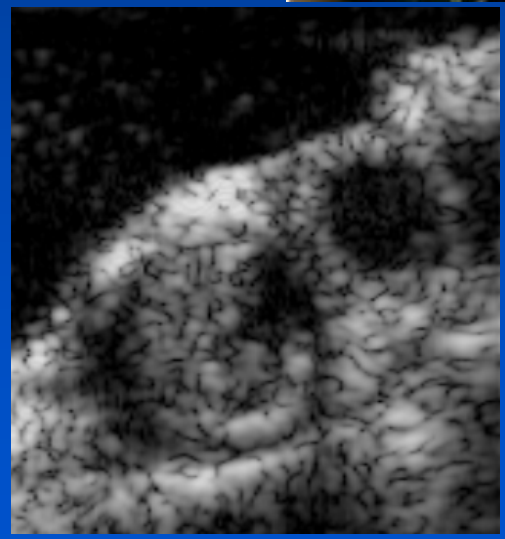
Image quality – during and 30 days after surgery



Intraoperative ultrasound

3-D visualization of carotid artery

GE Vingmed System fiVe

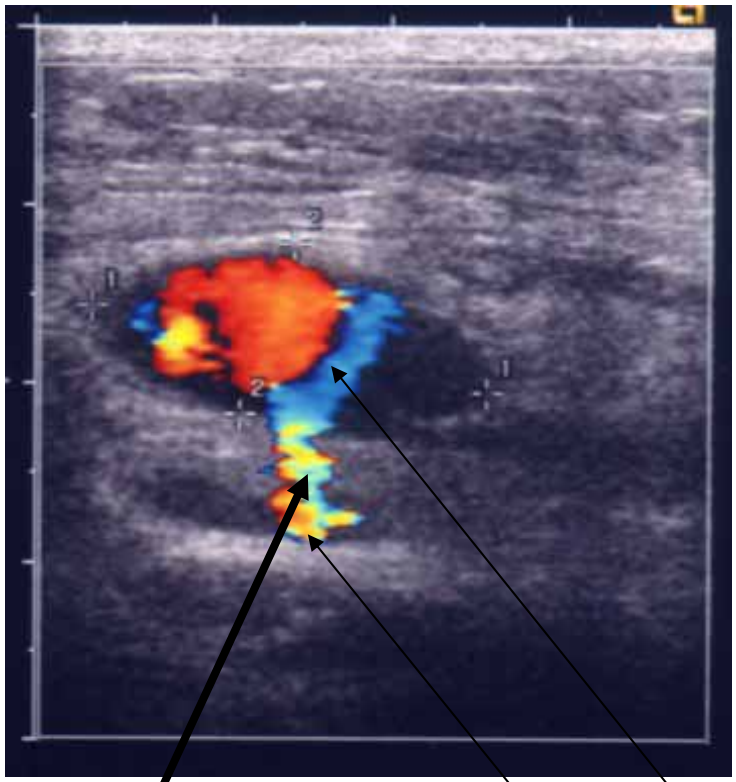


Carotid bifurcation with plaque formation

Ultrasound in diagnosis and treatment

Leakage from therapeutic puncture site in the groin

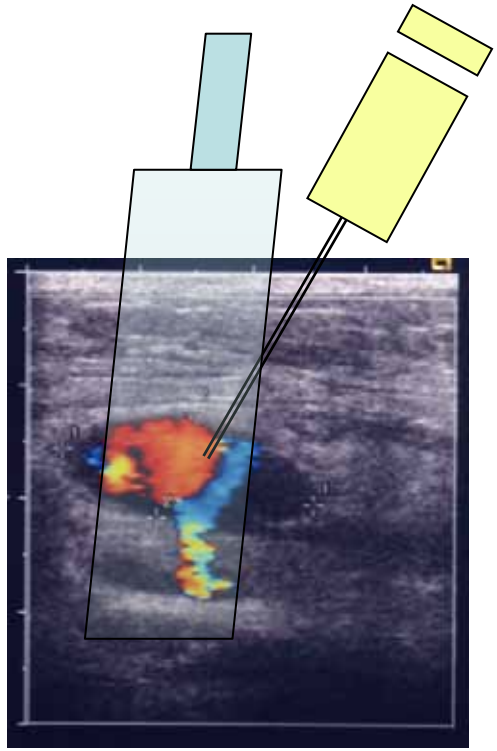
Diagnosis and ultrasound-guided treatment of a pseudoaneurysm in the groin



Site of leakage

Femoral artery

False aneurysm

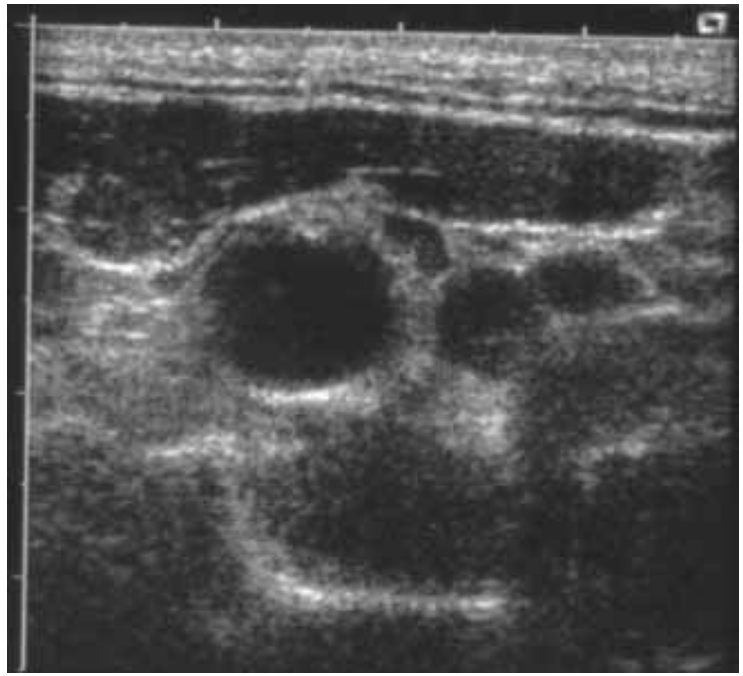


Thrombin injection

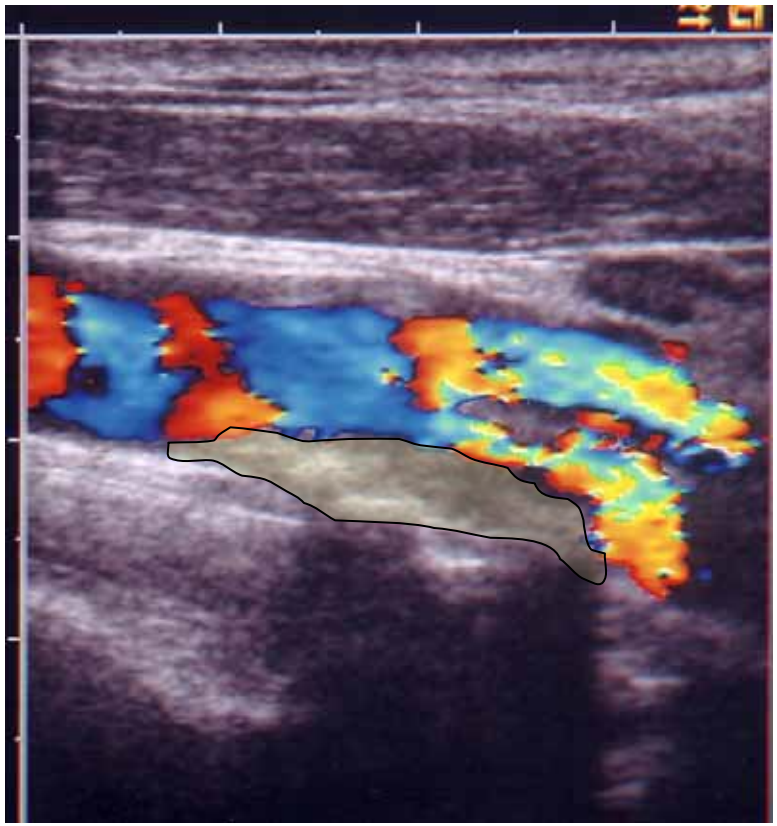
Better images

SURF-technique

Artefacts in B-mode scanning



Visualization of the vessel wall



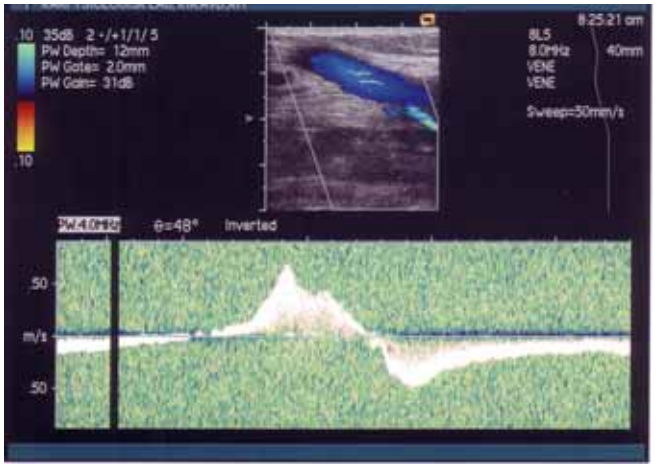
Carotid artery plaque

Intimal flap in carotid dissection

Other applications for ultrasound in vascular surgery

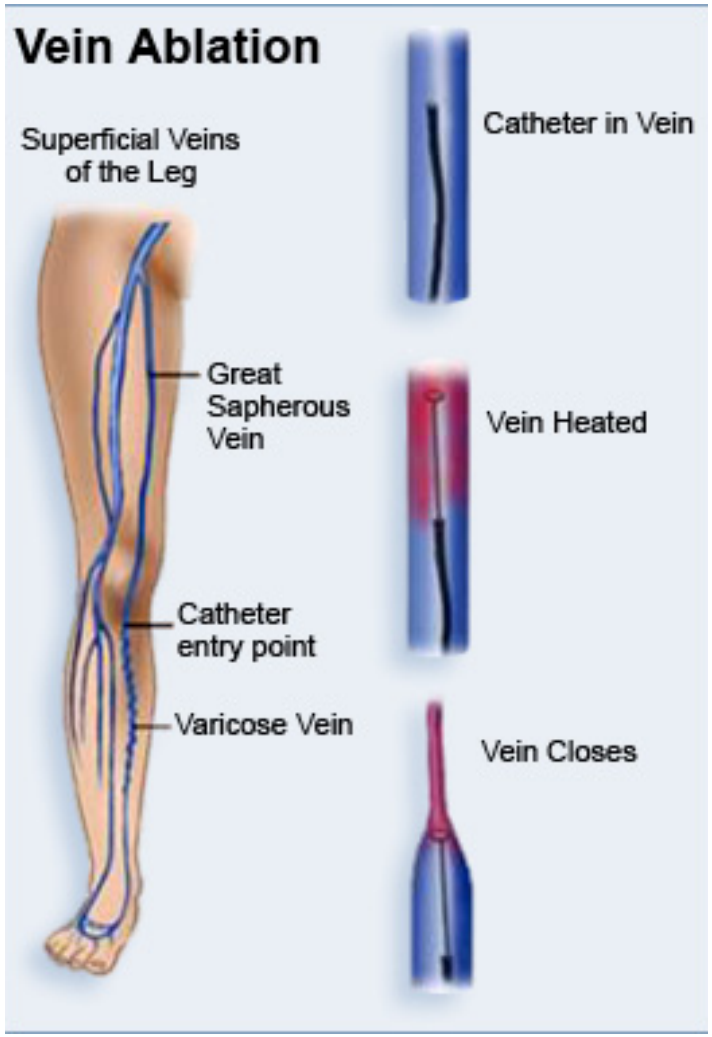
Venous disease and intravascular utlrasound

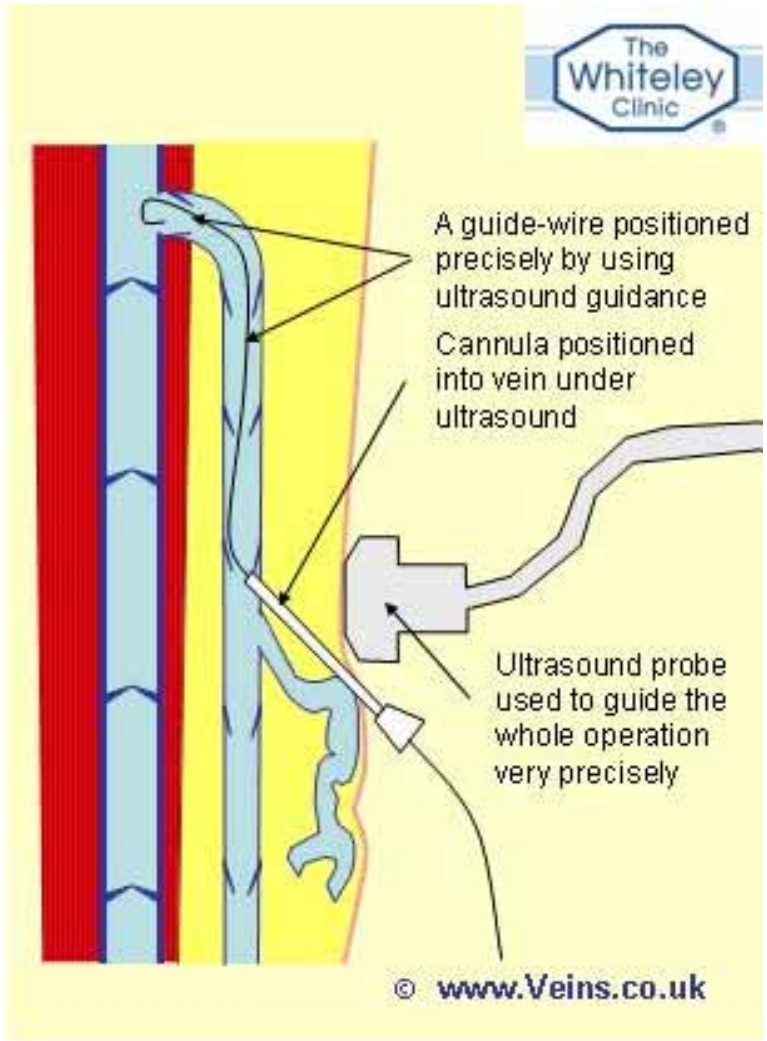
Ultrasound in venous disease



- Varicose veins
- Identify patent veins (DVT)
- Identify valvular insuffisiency
- To tailor surgical treatment
- Guide endovascular treatment

Thermal ablation of veins





Intravascular ultrasound

- Evaluate the result of an endovascular intervention
- Peroperative control
- Identify intravascular changes where other modalities fail to give sufficient information
- High costs

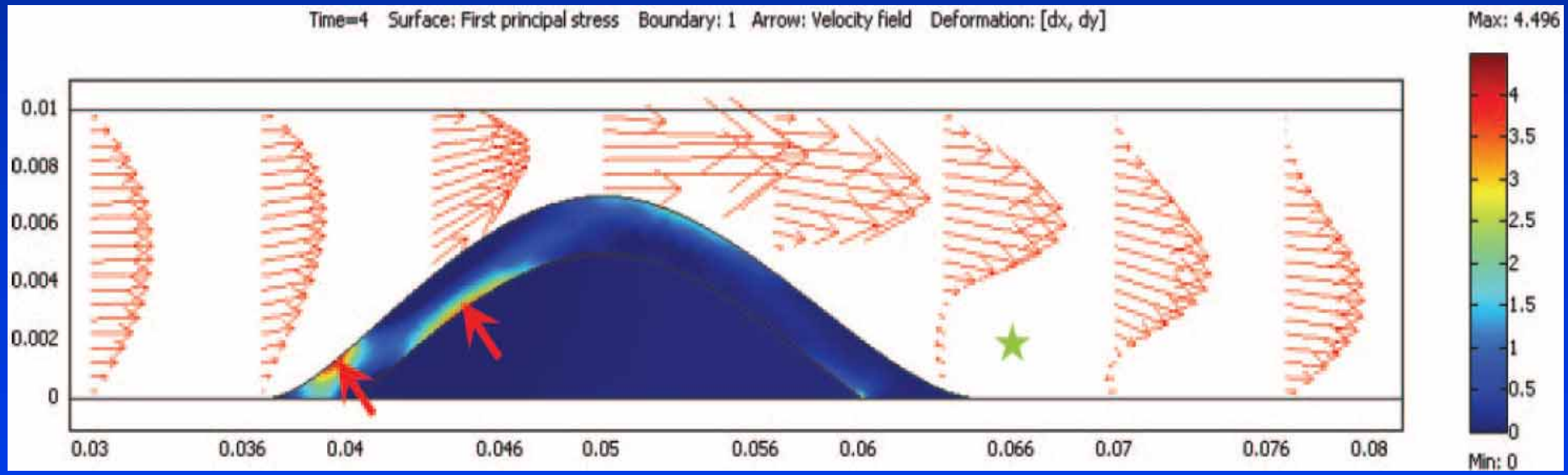
What about 3D ultrasound?

May be used for vessel anatomy, preoperative planning og hemodynamic studies

3D ultrasound

Display local flow vectors

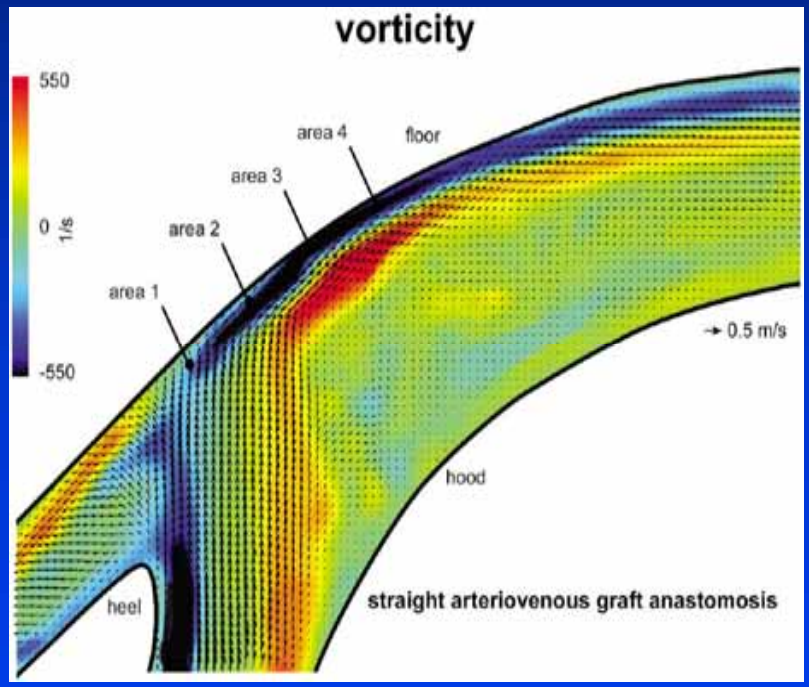
Li et al. 06



ES08

3D ultrasound

Display local flow vectors



Conclusion

- Could be used for diagnosis, treatment and follow-up of vascular interventions
- Operator dependent