Ultrasound in Vascular Surgery

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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

<table>
<thead>
<tr>
<th>Stenosis in %</th>
<th>&lt; 50</th>
<th>50-79</th>
<th>80-99</th>
<th>Occlusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity PSV&lt;sub&gt;ICA&lt;/sub&gt;</td>
<td>&lt;125 cm/sec</td>
<td>&gt;125 cm/sec</td>
<td>&gt;125 cm/sec</td>
<td>No flow*</td>
</tr>
<tr>
<td>Velocity EDV&lt;sub&gt;ICA&lt;/sub&gt;</td>
<td>&lt;140 cm/sec</td>
<td>&gt;140 cm/sec</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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

Vessel diameter

Rupture risk

5,5 cm
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 of 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

- Inflammation
- Movement
- Thrombosis, 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

National Center of Excellence, 3D Ultrasound in surgery
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 ultrasound
Ultrasound in venous disease

- Varicose veins
- Identify patent veins (DVT)
- Identify valvular insufficiency
- 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
3D ultrasound

Display local flow vectors
Conclusion

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