

# Place of Duplex in vascular access follow-up

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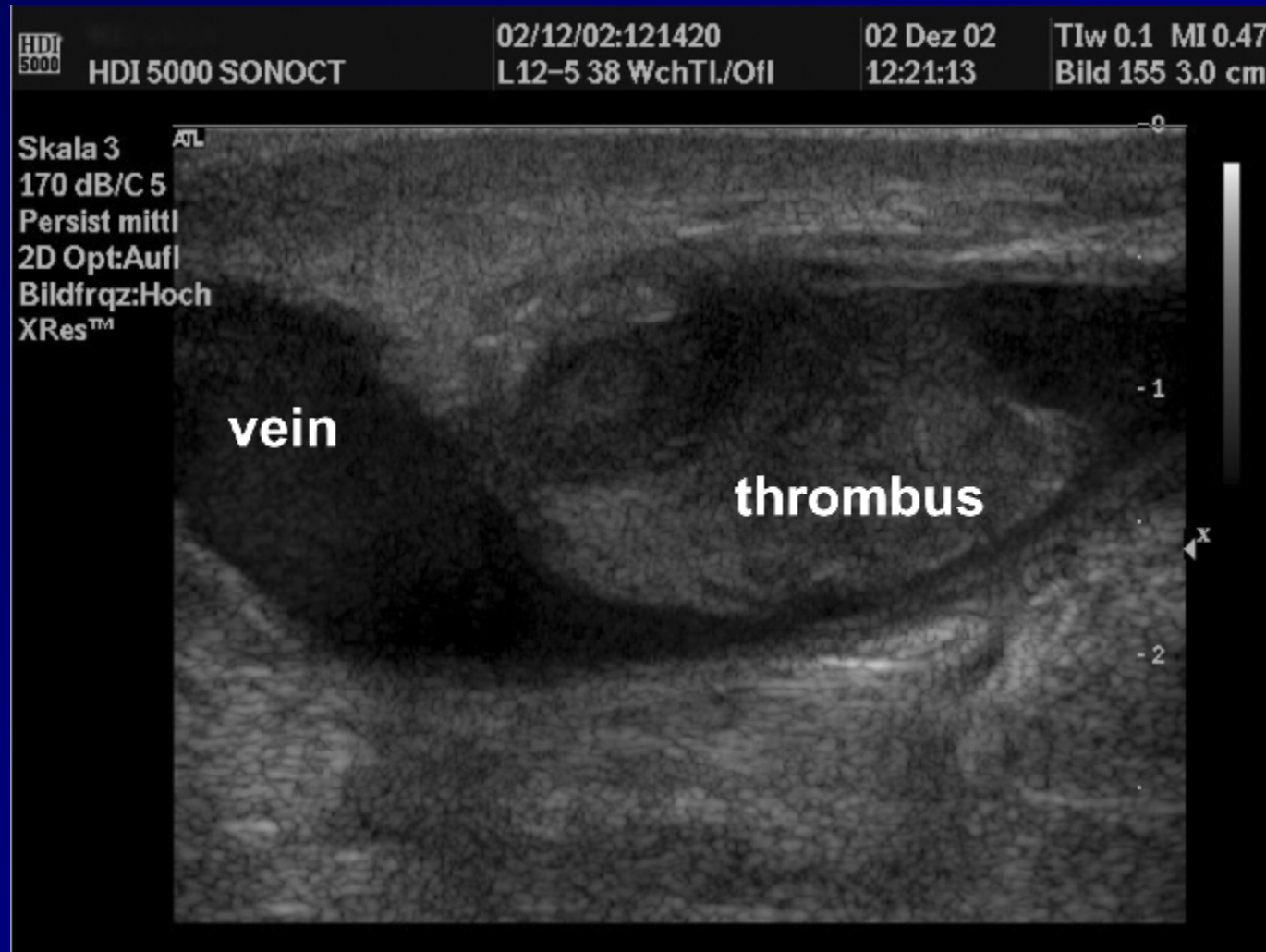
# Problems with AVF or grafts

- Thrombosis
- Stenosis
- Steal syndrome
- Aneurysm
- Pseudoaneurysm

# Thrombosis

- No flow or only venous blood
  - Non compressible vein or graft
  - US:
    - extension of thrombosis
    - structure of thrombus
    - opening of the feeding artery and proximal vein
- decision for thrombectomy

**B-mode image of a thrombosis in the venous outflow tract, showing both fresh (low echogenicity) and older (high echogenicity) thrombotic material**



Wiese, P. et al. Nephrol. Dial. Transplant. 2004 19:1956-1963;

# Stenosis

## ■ AVF:

- juxta-anastomotic
- centrally in the outflow tract (bifurcation of the vein, scarring puncture site, venous valve)
- central vein stenosis (CVC)

## ■ Graft:

- venous outflow tract at the site of anastomosis between the graft and the vein

## ■ Clinical examination:

- inspection of AVF (at elevation congested vein, only systolic murmur etc)
- problems with bleeding after cannulation
- elevated venous inflow pressure

# Stenosis

## ■ US:

- longitudinal and transverse plane from anastomosis into the central venous system
- haemodynamic relevant stenosis:
  - *direct visualization of the area of narrowing*
  - *luminal diameter reduction > 50%*
  - *peak systolic flow velocity increased*
  - *post-stenotic turbulence (aliasing phenomena)*
  - *indirect signs: high resistance Doppler waveform, reduction in blood flow*
- sensitivity of US from 76 to 87% against angiography

# Steal syndrome

- Frequent in pts with forearm and upper arm AVFs and grafts
- AVF steals retrograde flow from the hand via palmar arch ( about 40%) – *steal phenomena*
- Steal phenomena converts to steal syndrome
  - pain at rest
  - pain during HD
  - acral necrosis
- US:
  - Doppler spectrum at reactive hyperemia – impaired capacity of palmar arch arteries to vasodilate

# Aneurysm and pseudoaneurysm

- At sites of vessel destruction after repeated cannulation
- US immediate distinguish pseudoaneurysm from haemathoma
- To determine extension of the aneurysm and to demonstrate thrombotic material within sac

# Measurement of blood flow by US

- CDU imaging of the feeding brachial in the middle of the upper arm with flow measurement
- Diameter of feeding artery by B-mode and Doppler spectra for time average velocity (TAV) – calculated by US machine
- Blood flow in PTFE grafts investigated by CDU along the entire access
- Flow calculation in venous outflow is not useable: variations in internal diameter , turbulent flow and vibrations due to superficial localization and arterialization of the vein



- To explain the place of DU in the overall management of vascular accesses
- To explain the advantages and drawbacks of DU imaging
- To explain why it is useless to describe stenoses with no concomitant flow measurement



# Evaluation

- Clinical evaluation
- Duplex sonography
- *DSA*
- *CE-MRA*
- *CTA*

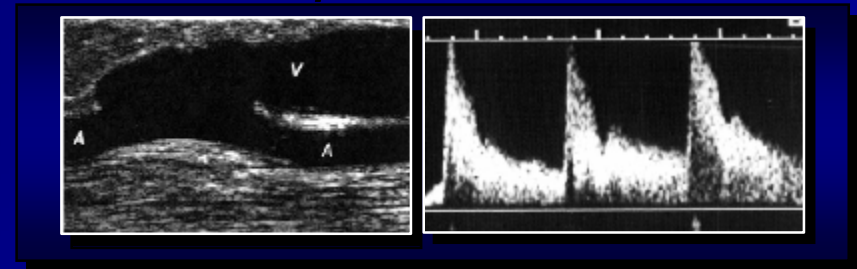
# Agenda

- Ultrasound as a method
- **Usefulness of ultrasound**
  - pre-operative
  - intra-operative
  - evaluation of vascular access
- **Limitations of ultrasound**
- Conclusions

# ULTRASOUND AS A METHOD

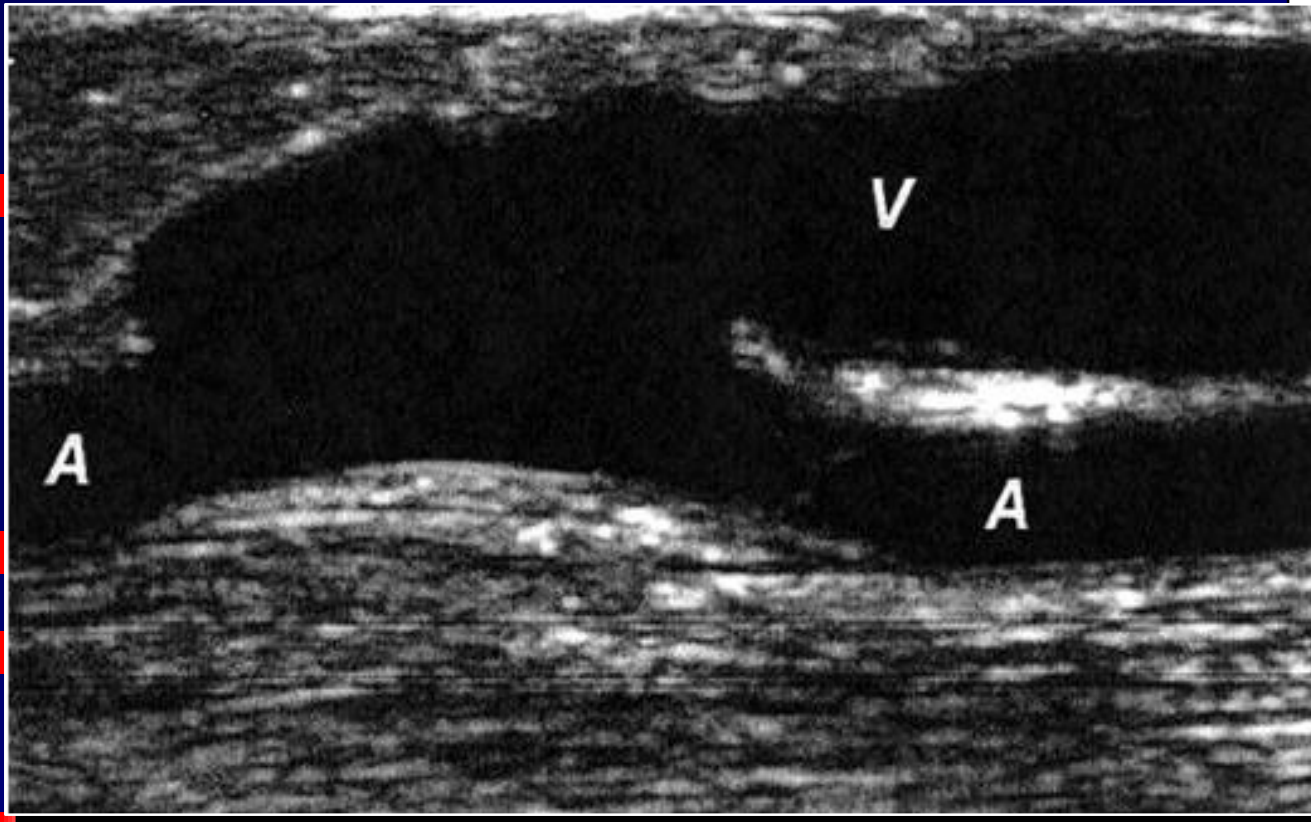


- Examination with B-mode for morphology and Doppler mode for haemodynamic – *duplex sonography*

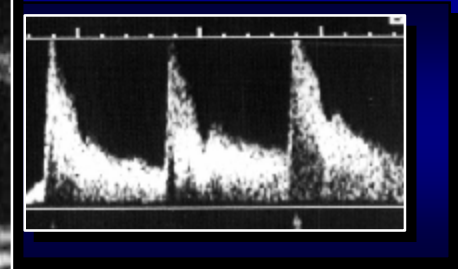


- Non-invasive method
- Linear probe with frequency 7 MHz or more for B-mode and 5 MHz or higher for Doppler
- Ease and safety method
- **Wide spread availability**
- Low cost

# ULTRASOUND AS A METHOD



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# ULTRASOUND AS A METHOD



- Examining  
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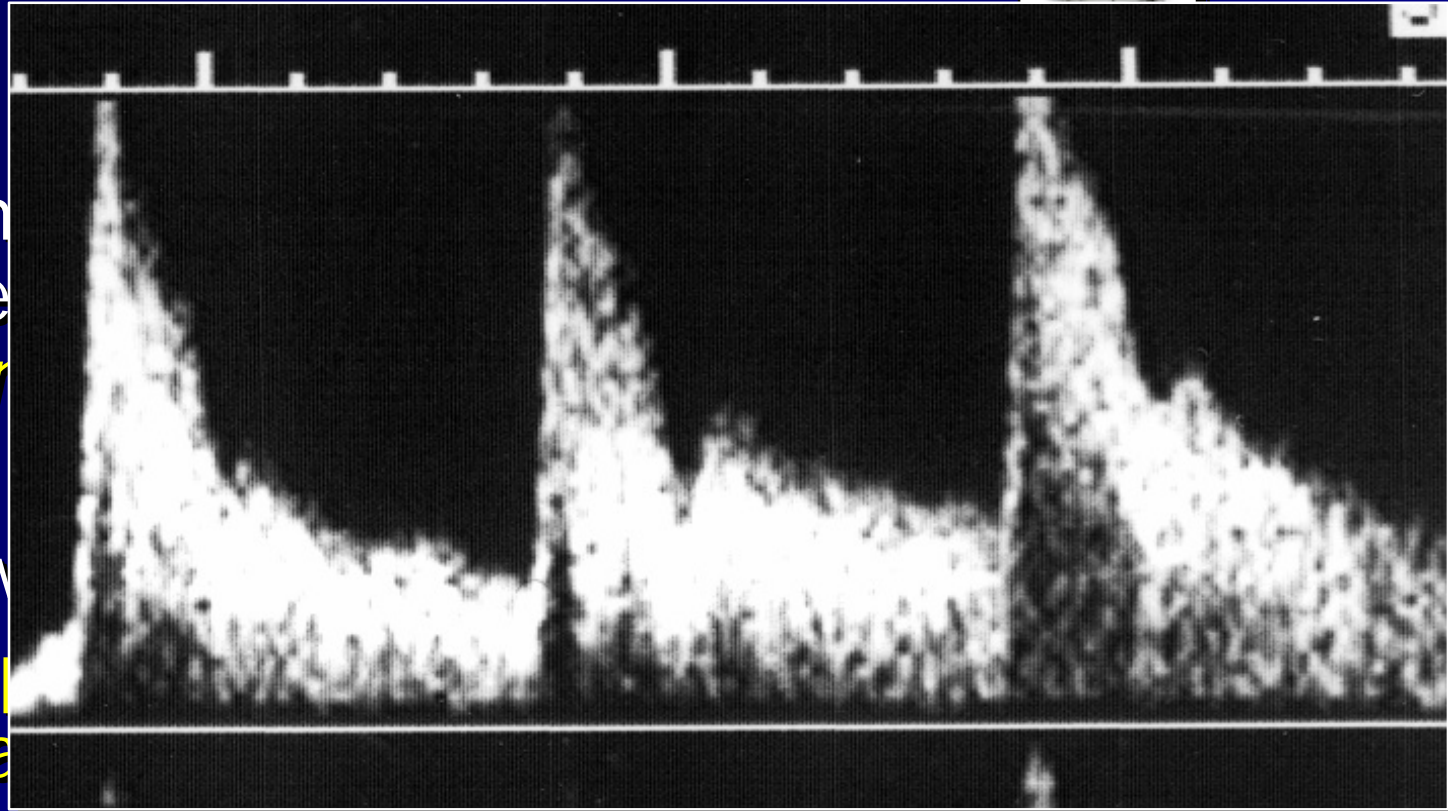
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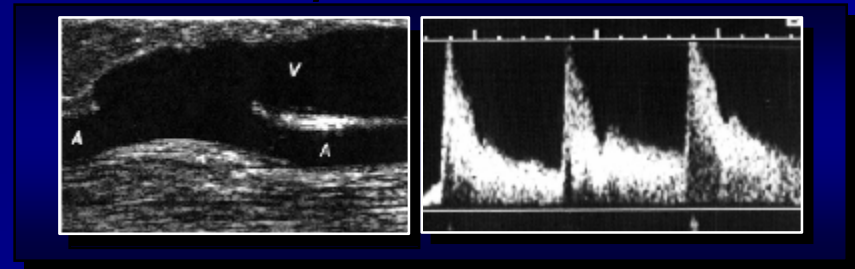
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# ULTRASOUND AS A METHOD



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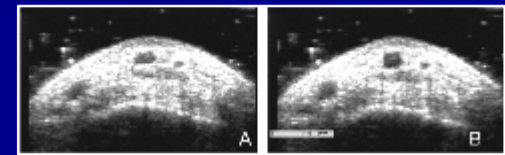
# USEFULNESS OF ULTRASOUND- PREOPERATIVE EVALUATION OF VESSELS

## ■ Venous scan:

- *Venous appearance and suitability for cannulation* - 46.5% visibility of veins on clinical exam (Malovrh M., Am J Kidney Dis 2002;39:1218-25.)

- *Venous diameter and distensibility*

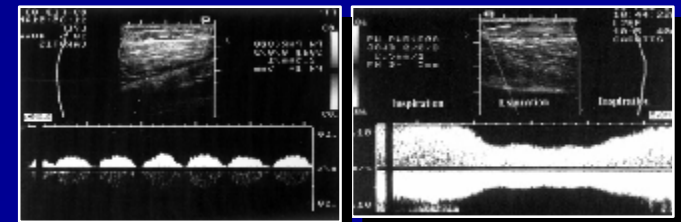
- longitudinal or transverse section
- after 2 minutes application of a tourniquet



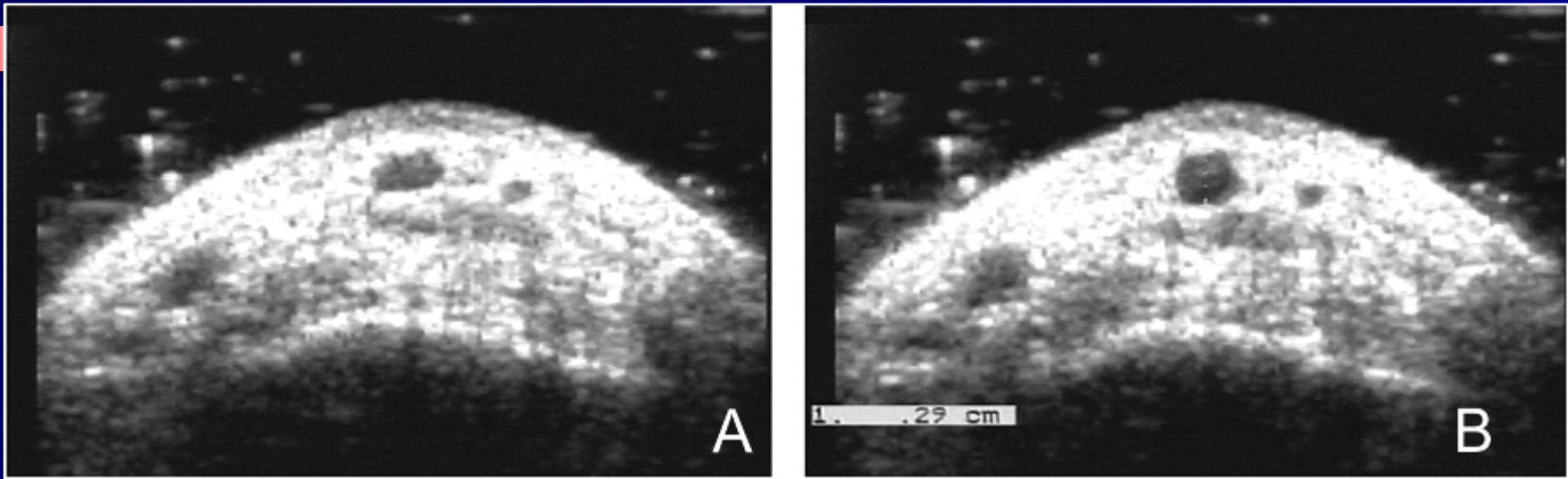
(Planken N., NDT 2006;21:802-806.)

- *Venous Doppler*

- shape of Doppler waveform
- changing of DW with respiration



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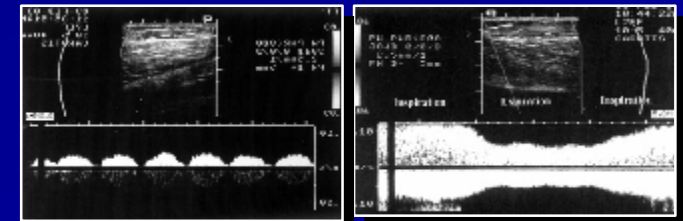


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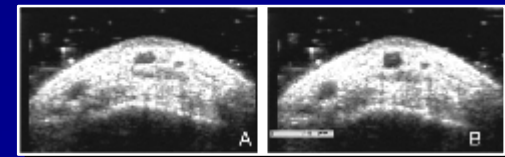
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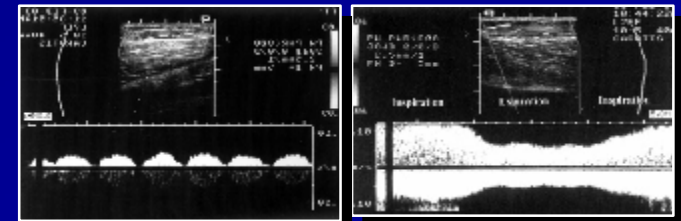
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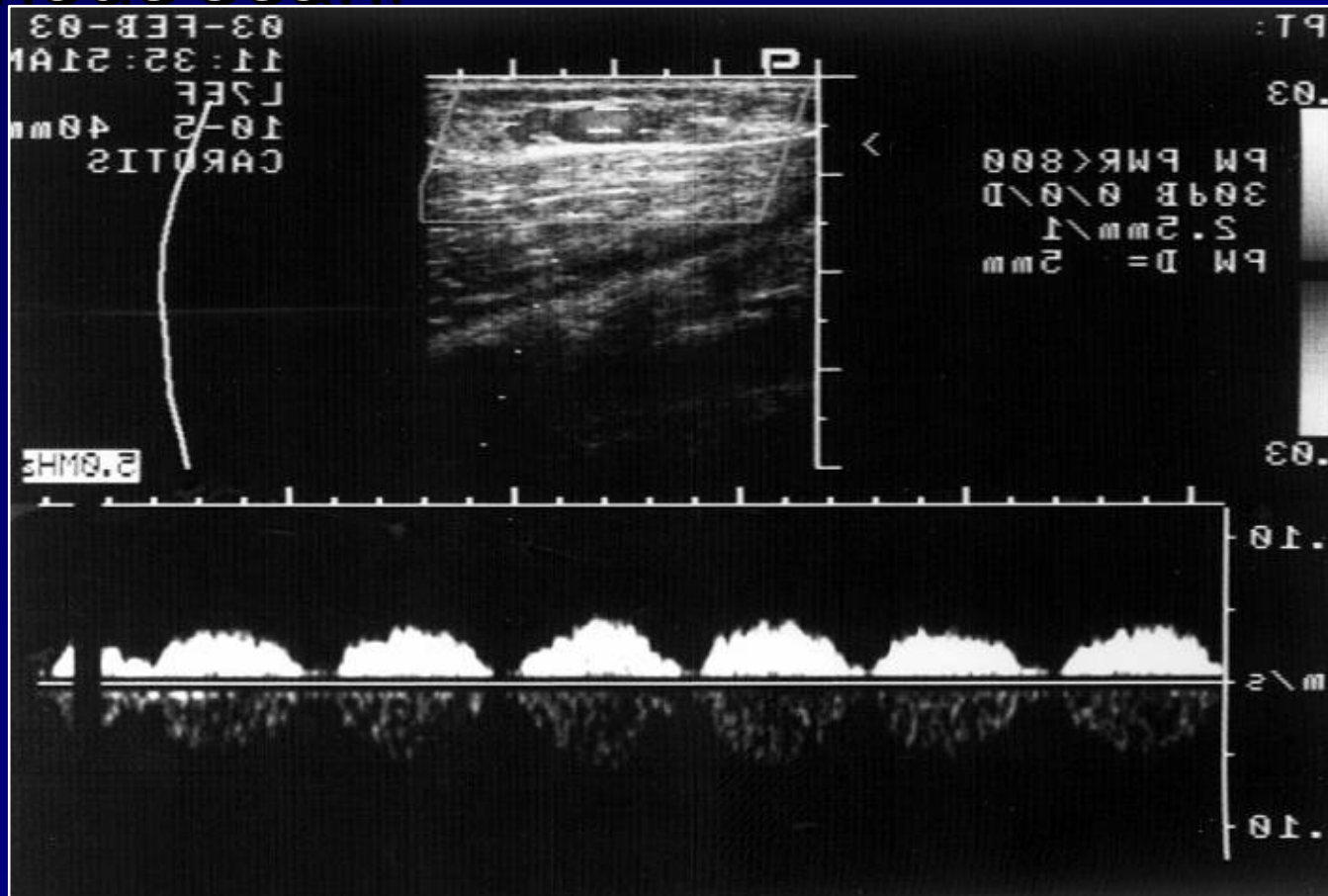
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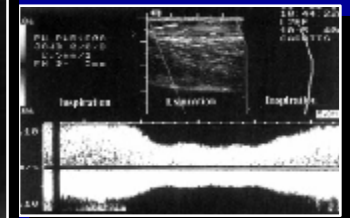
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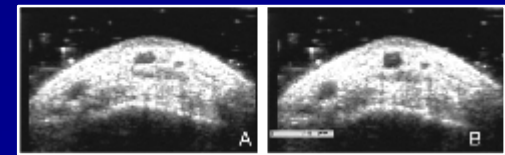
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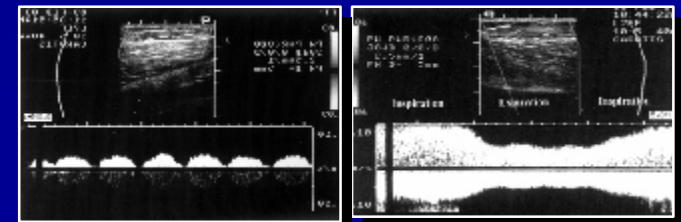
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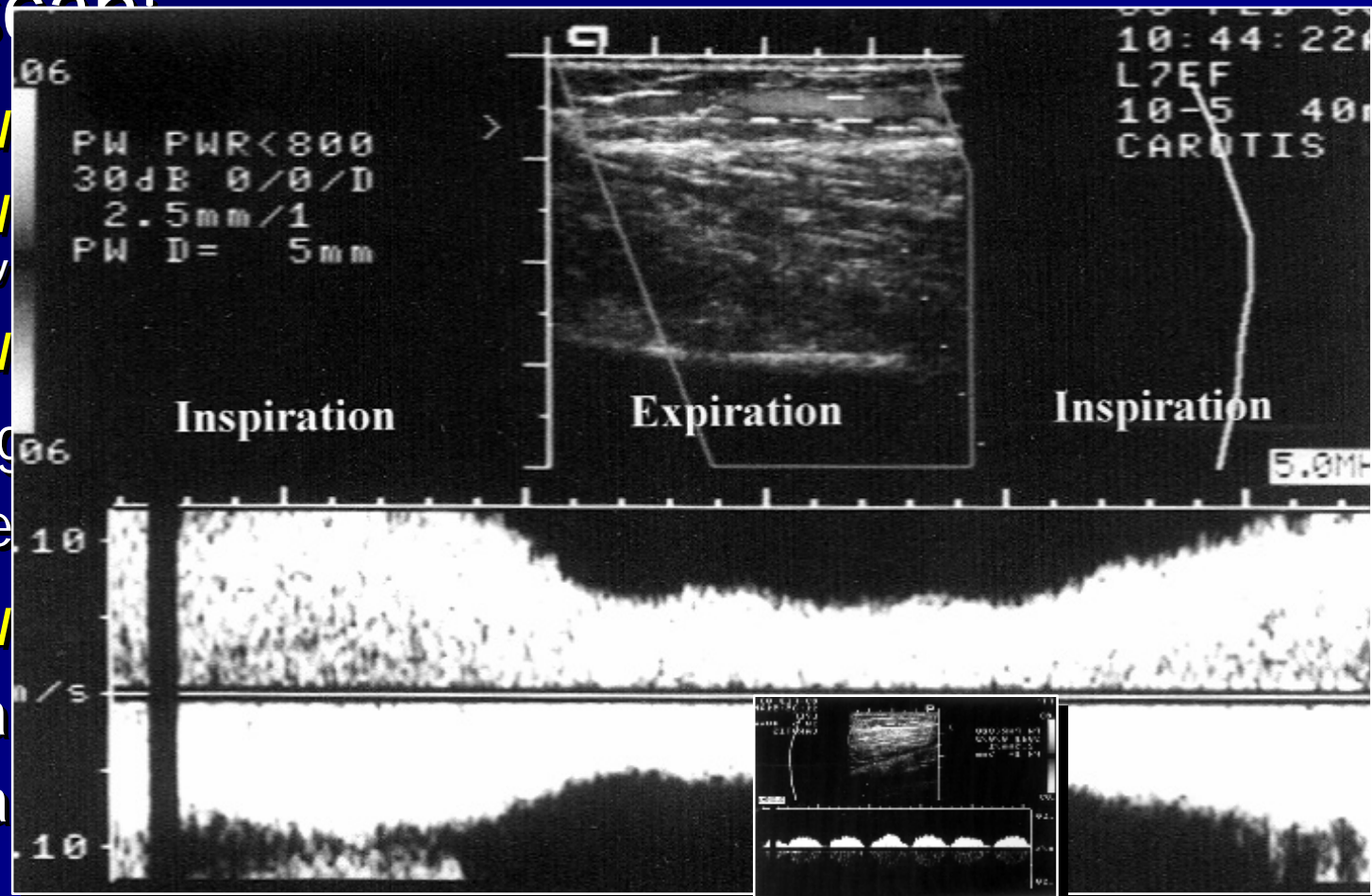
- long

- after

■ Venous

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# USEFULNESS OF ULTRASOUND- PREOPERATIVE EVALUATION OF VESSELS

## ■ Arterial scan:

### ■ *From subclavian artery to the radial and ulnar artery*

- stenosis and peak systolic velocity

### ■ *Anatomical variations*

- proximal origin of ulnar and radial artery in the upper arm

### ■ *Calculation of blood flow*

- diameter and TAV velocity

# USEFULNESS OF ULTRASOUND- PREOPERATIVE EVALUATION OF VESSELS

## ■ Arterial scan:

### ■ *Arterial diameter*

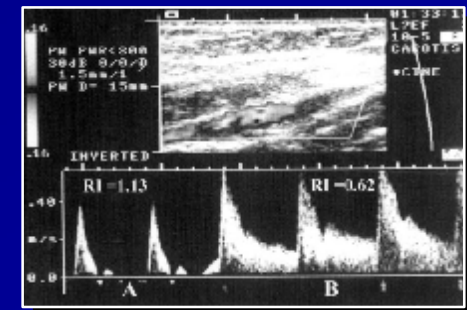
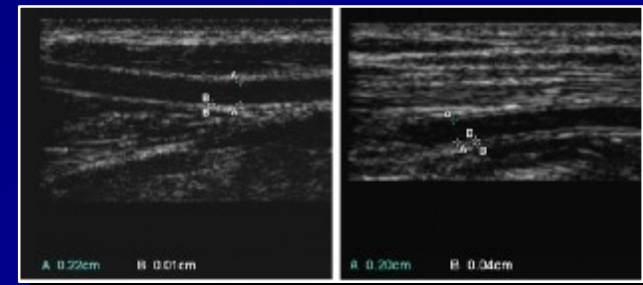
- from intima to intima perpendicular to the wall

### ■ *IMT and structure of wall*

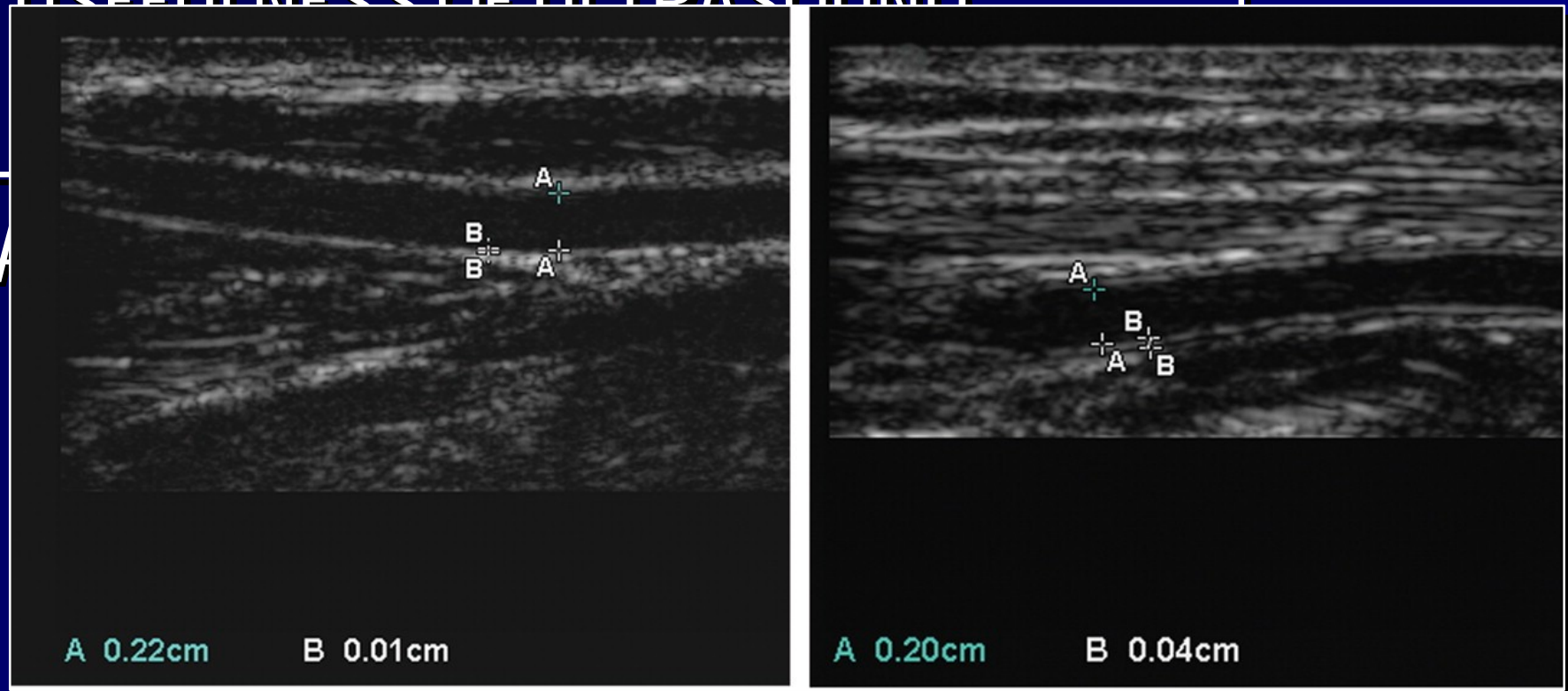
- smoothness of intima and calcifications

### ■ *Hyperaemic response*

- lower peripheral resistance like after AV F construction

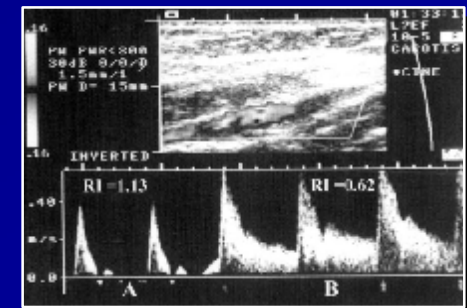


# USEFULNESS OF ULTRASOUND



## ■ *Hyperaemic response*

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# USEFULNESS OF ULTRASOUND- PREOPERATIVE EVALUATION OF VESSELS

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### ■ *Arterial diameter*

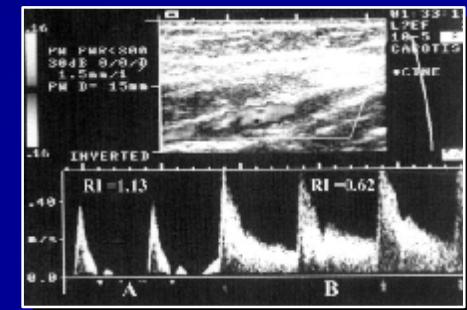
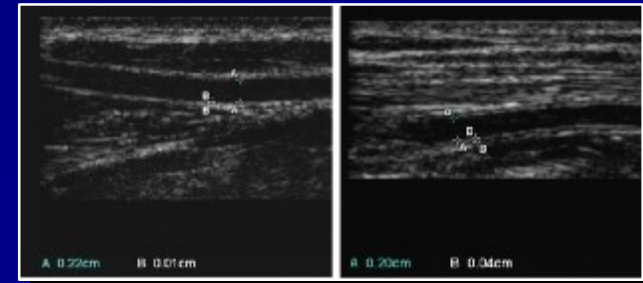
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## ■ Arterial stenosis

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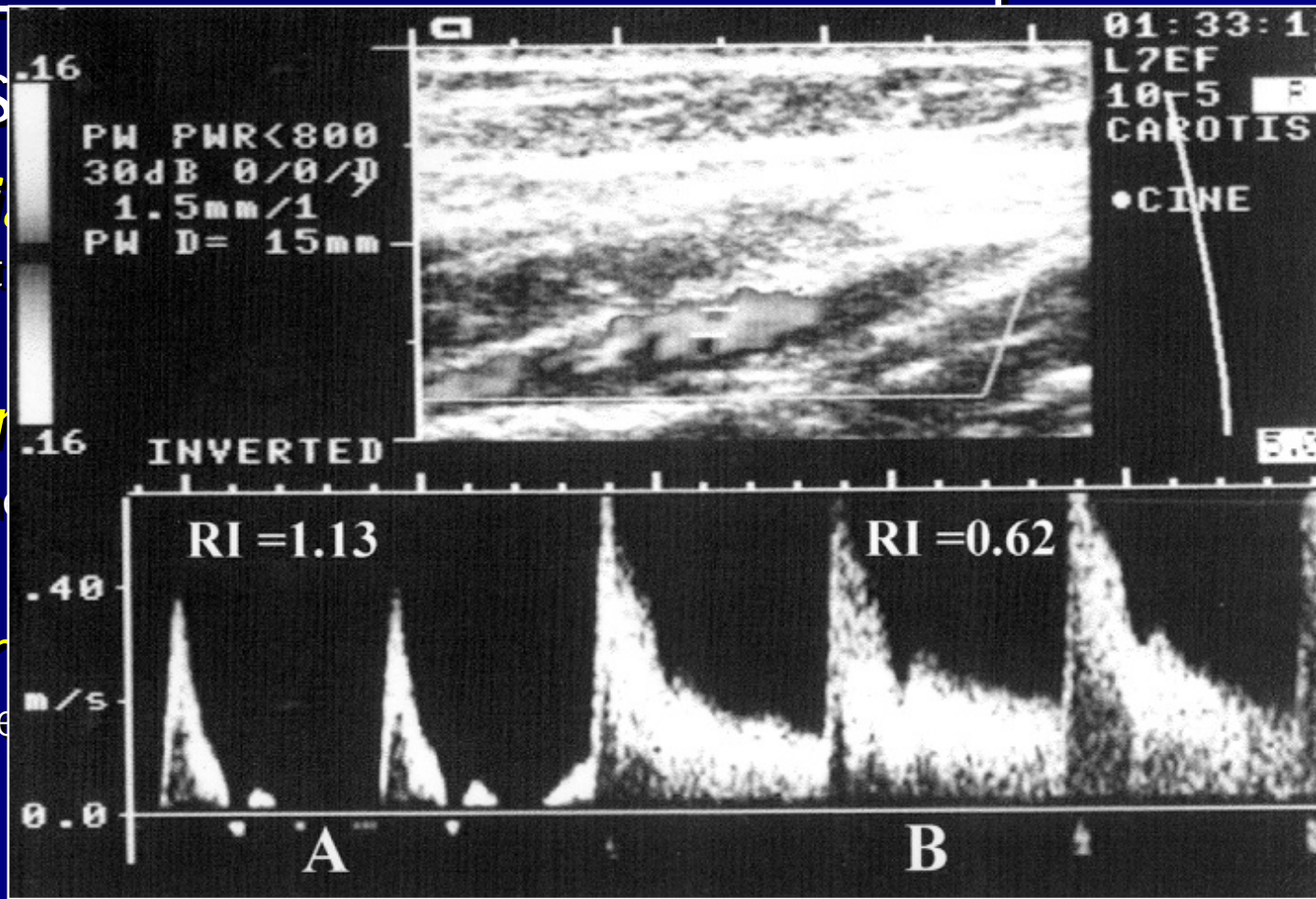
- from intima

### ■ IMT and plaque

- smoothness

### ■ Hypertension

- lower perfusion



# USEFULNESS OF ULTRASOUND- PREOPERATIVE EVALUATION OF VESSELS

## ■ Arterial scan:

### ■ *Arterial diameter*

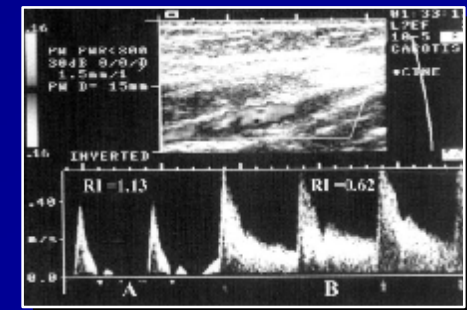
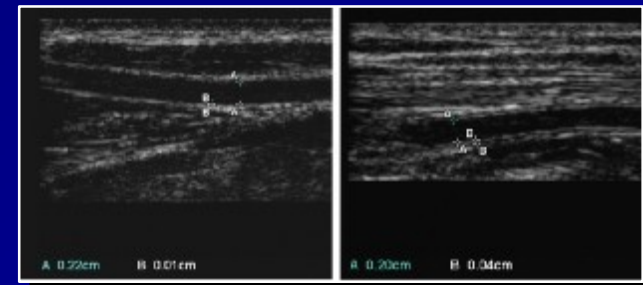
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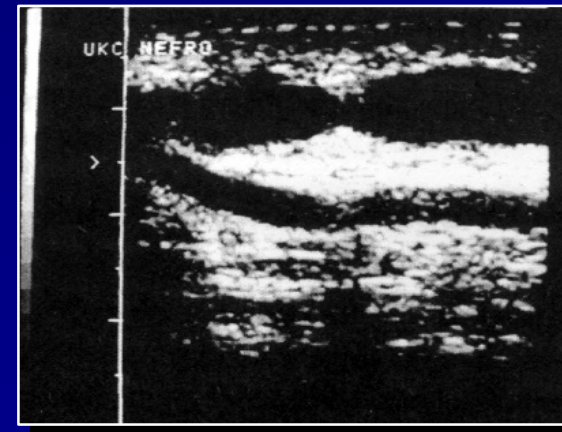
# USEFULNESS OF ULTRASOUND- INTRA-OPERATIVE ASSESSMENT OF BLOOD FLOW

- Direct measurement of blood flow:
  - Handheld flow probe around draining vein (MedStim system):
    - NFAVF : FAVF – 98 mL/min:230 mL/Min (Saucy F, et al. Nephrology Dialysis Transplantation 2010;25:862-867)
  - Perivascular flow probe (Transonic System):
    - NFAVF : FAVF – 109mL/min:208 mL/min (Berman SS, et al. J Vasc Access 2008;9:241-247)
- Selection AVFs require immediate revision

# USEFULNESS OF ULTRASOUND-EVALUATION OF VASCULAR ACCESS

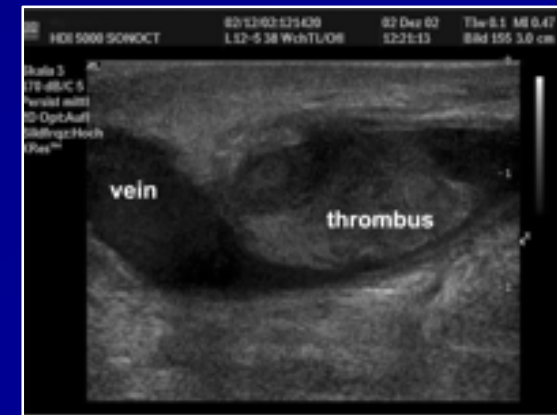
## ■ Stenosis:

- valuable and reliable screening tool in managing clinically suspected AVF stenosis
- velocities and blood flow calculation



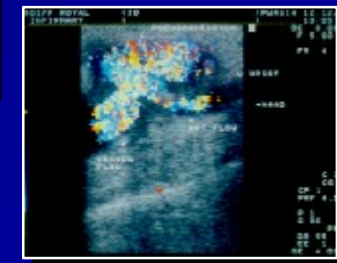
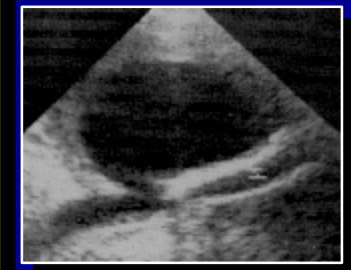
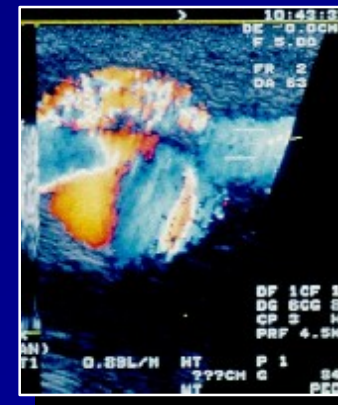
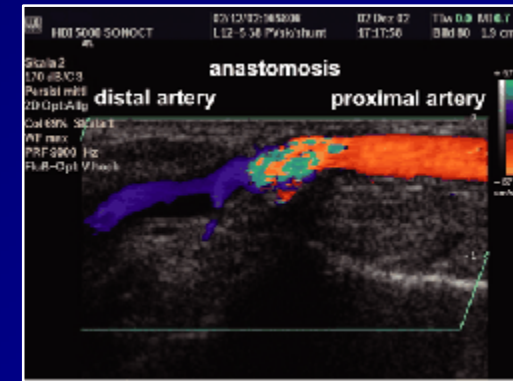
## ■ Thrombosis:

- detection of thrombus in AVF
- flow through feeding artery and proximal vein



# USEFULNESS OF ULTRASOUND-EVALUATION OF VASCULAR ACCESS

- Steal syndrome:
  - by investigating the parts proximal and distal to the anastomosis.
- Aneurysm and pseudoaneurysm:
  - CDU flow imaging can especially distinguish pseudoaneurysms from haematoma
  - particularly suitable to determine the extension of the aneurysm and to demonstrate thrombotic material within the aneurysmatic sac



## LIMITATIONS OF ULTRASOUND IN PRE-OPERATIVE EVALUATION-STUDIES LIMITATIONS

- Different outcomes of AVF in studies exam the effect of *pre-operative evaluation*:
  - Immediate outcome
  - Functional primary patency
  - AVF survival
  - Early and primary failure

## LIMITATIONS OF ULTRASOUND IN PRE-OPERATIVE EVALUATION-STUDIES LIMITATIONS

- Individual pre-operative ultrasound criteria and relation to AVF outcome:
  - Arterial criteria:
    - *Internal diameter of radial arteries:* 1.5 to 2.0 mm
    - *Quality of arterial wall:*
      - IMT thickness– good correlation with histology and AVF failure
      - Influence on internal diameter and elasticity of wall
      - Calcifications
    - *Hyperemic response* – heterogeneous studies, difficult to compare, useful adjunct in the arteries of borderlines quality and caliber

## LIMITATIONS OF ULTRASOUND IN PRE-OPERATIVE EVALUATION-STUDIES LIMITATIONS

- Individual pre-operative ultrasound criteria and relation to AVF outcome:
  - Venous criteria:
    - *internal diameter of veins*: 2.0 to 3.0 mm
      - day-to-day variation
      - ambient temperature
      - patient position
    - *distensibility* – not many data , 2 studies , different technology!!
    - *meaning of accessory veins*

# LIMITATIONS OF ULTRASOUND IN PRE-OPERATIVE EVALUATION

- Currently is no universal specific cut-offs on vessel anatomy or even measures of distensibility and vessels mechanics.
- Many patient-specific medical history and underlying disease process not detected by ultrasound involving arteries and veins that may change treatment decisions prior to surgery .

## LIMITATIONS OF ULTRASOUND IN FOLLOW OF VASCULAR ACCESS

- DUS is a valuable diagnostic tool prior to DSA.
- DUS enables better selection to DSA puncture site for contrast media injection.
- DUS is a valuable diagnostic modality to detect upper extremity venous outflow stenosis located from the wrist to the axilla.

# LIMITATIONS OF ULTRASOUND IN FOLLOW OF VASCULAR ACCESS

## ■ DUS is:

- *Time consuming,*
- *Observer dependent*
- *Shows poor performance*

## – to assess

- *Arterial inflow stenoses*
- *Juxta anastomotic stenoses*
- *Central arterial or central venous stenoses*

# FUTURE PERSPECTIVE

- Recommendations for preoperative assessment should be completed:
  - *Assessment protocols*
  - *Combination of arterial, venous and cardiac parameters*
  - *Influence of AVF on local and systemic hemodynamics*

# CONCLUSIONS

1. Pre-operative ultrasound could predicts AVF patency and maturation.
2. Ultrasound is particular benefit when physical examination is insufficient but has little added when physical examination is satisfactory.

# CONCLUSIONS

3. Results of ultrasound are observer dependent.
4. Reproducibility of superficial venous diameter and distensibility is poor, affected also by daily variation and applied venous congestion pressure.

# CONCLUSIONS

5. It is essential to optimize, validate and standardize pre-operative parameters that are used in the work-up prior to vascular access creation.
6. Beside physical examination, DUS is useful tool for AVF or AV graft evaluation during HD treatment and enables better decisions about further diagnostic and treatment methods.

**Thank you for your attention**