CONTROVERSES ET ACTUALITÉS EN CHIRURGIE VASCULAIRE
CONTROVERSIES & UPDATES IN VASCULAR SURGERY
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# Doppler detection of significant access stenosis

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www.cacvs.org

**Disclosure**

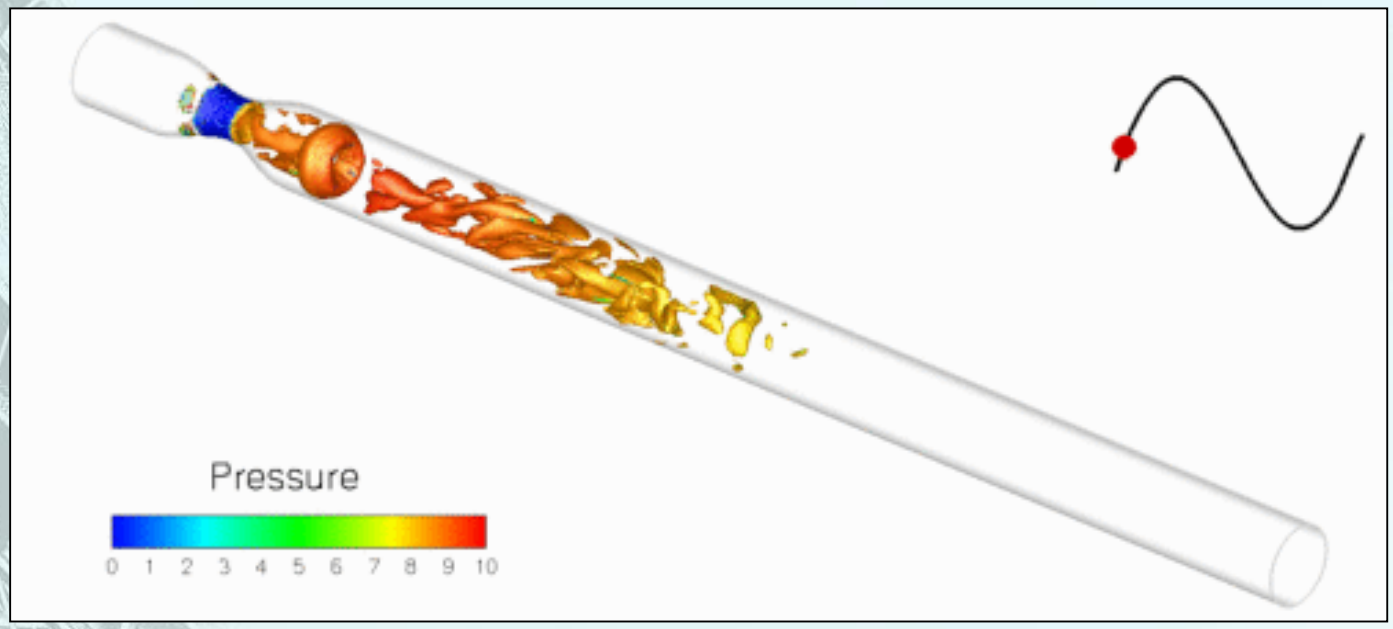
Speaker name:

**.....Jan Malik**

- ☐ I have the following potential conflicts of interest to report:
- ☐ Consulting
- ☐ Employment in industry
- ☐ Shareholder in a healthcare company
- ☐ Owner of a healthcare company
- ☐ Other(s)
- ➢ I do not have any potential conflict of interest

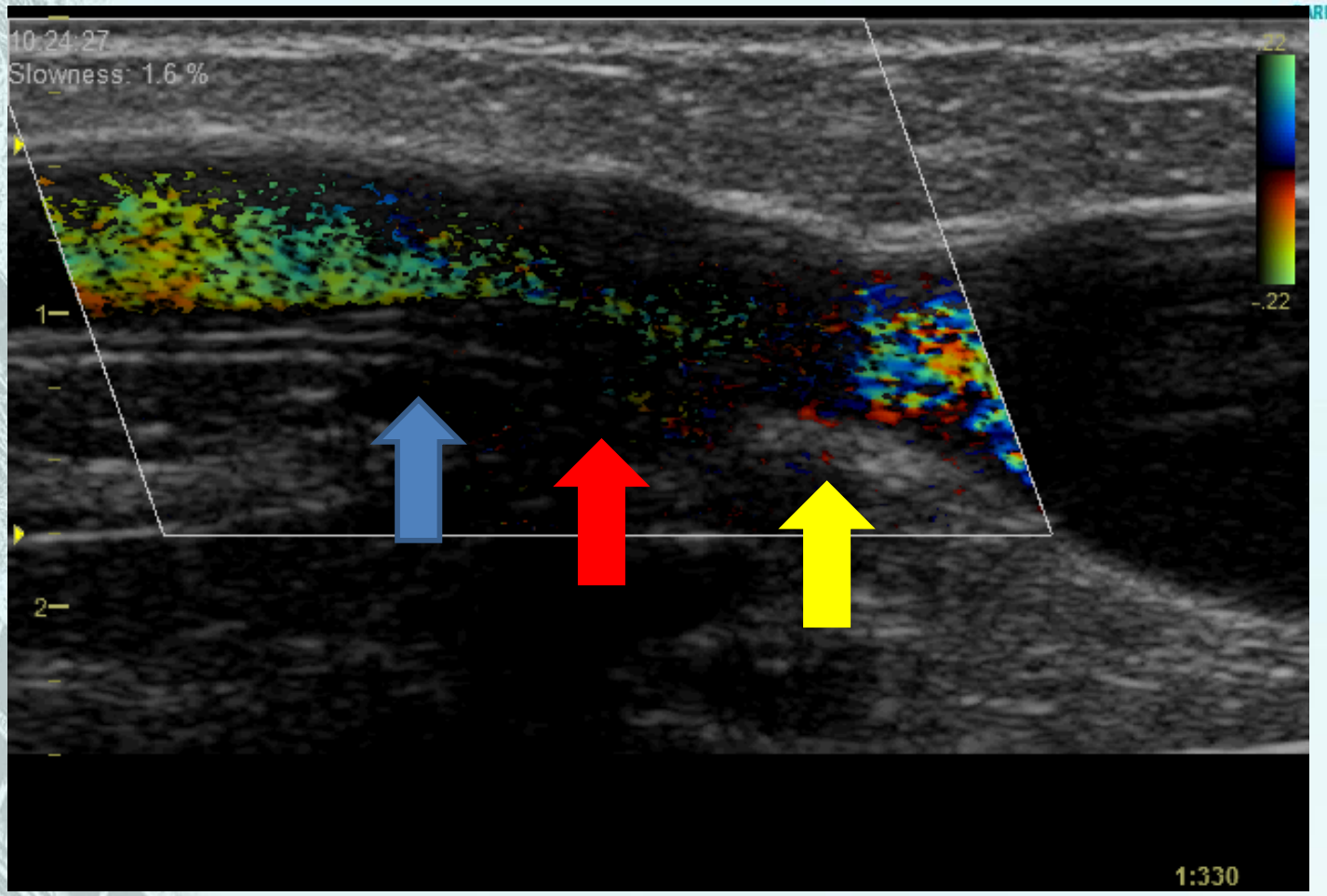
# Stenosis by fluid dynamics

**Stenosis = pressure loss due to the flow reverberation, which constricts the flow jet**




https://engineering.purdue.edu

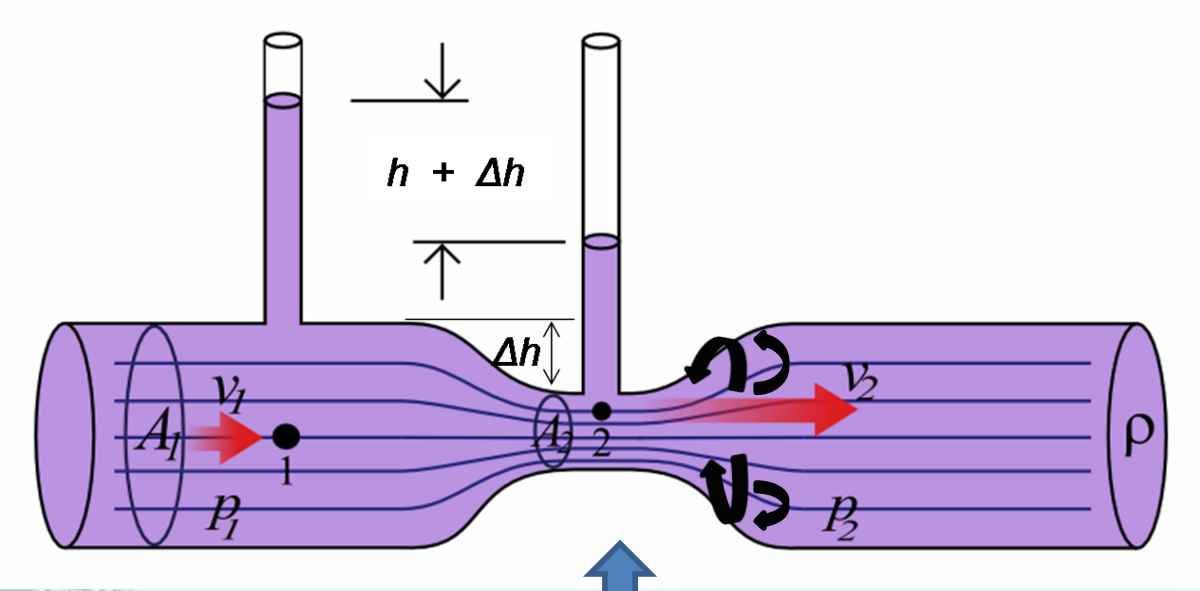
# Flow constriction




**Where is the flow velocity highest?**

# Local effect of stenosis: Venturi

**Static pressure**




**Wall shear stress**

# Local effects of stenosis
# Wall shear stress (WSS)

- **Very high velocity** (~ ↑WSS): activation of von Willebrand factor, endothelium denudation

- **Low velocity, changing vector** (~ ↓WSS): acceleration of atherogenesis and probably also of intimal hyperplasia

WSS ≈ (velocity*viscosity)/diameter

# The effect of stenosis length

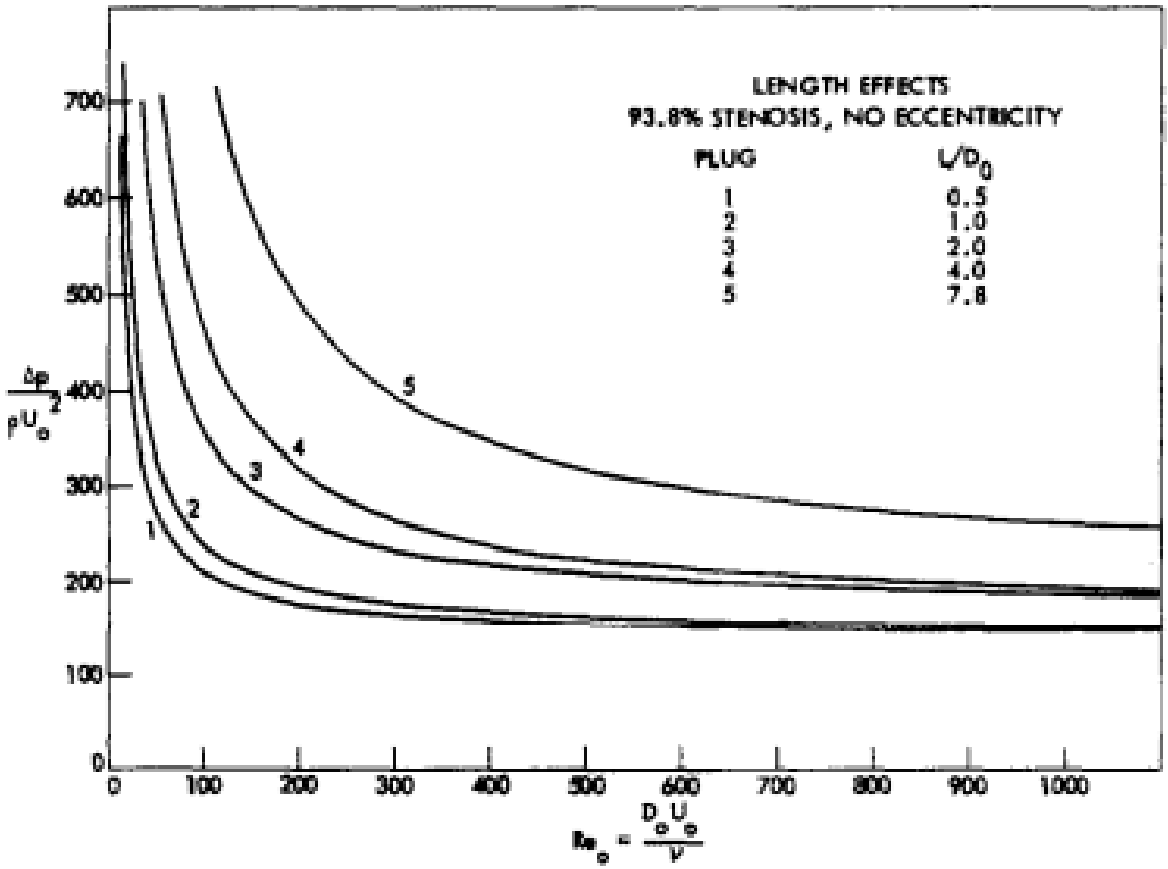
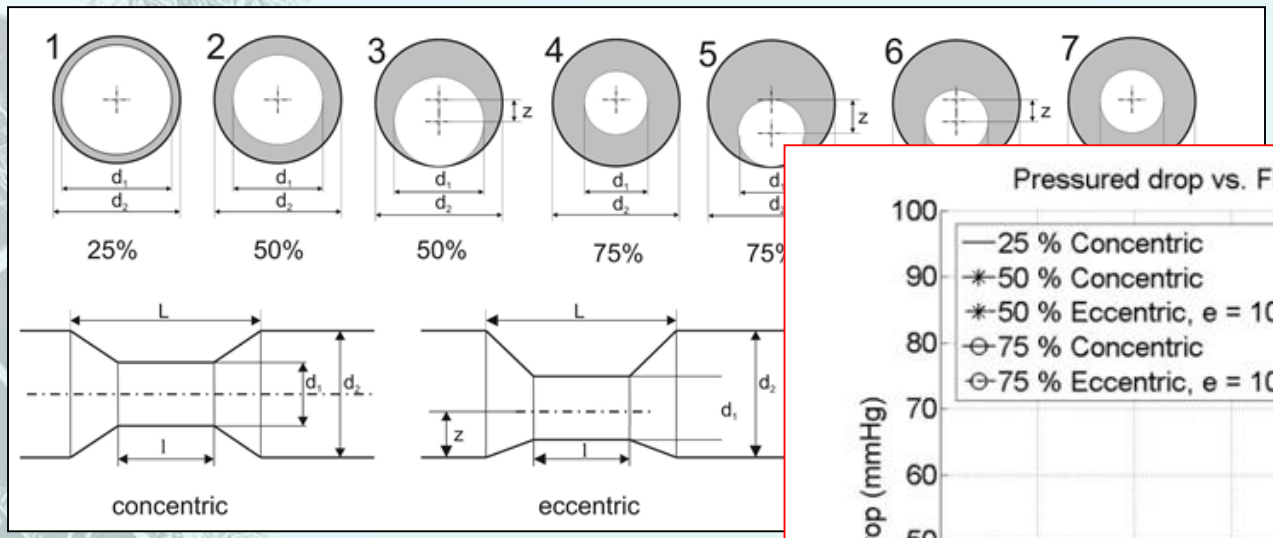



Fig. 5. Comparison of pressure-drop curves for blunt plugs of varying lengths.

Seeley BD, Young DF, J Biomechanics 1976

# Stenosis geometry



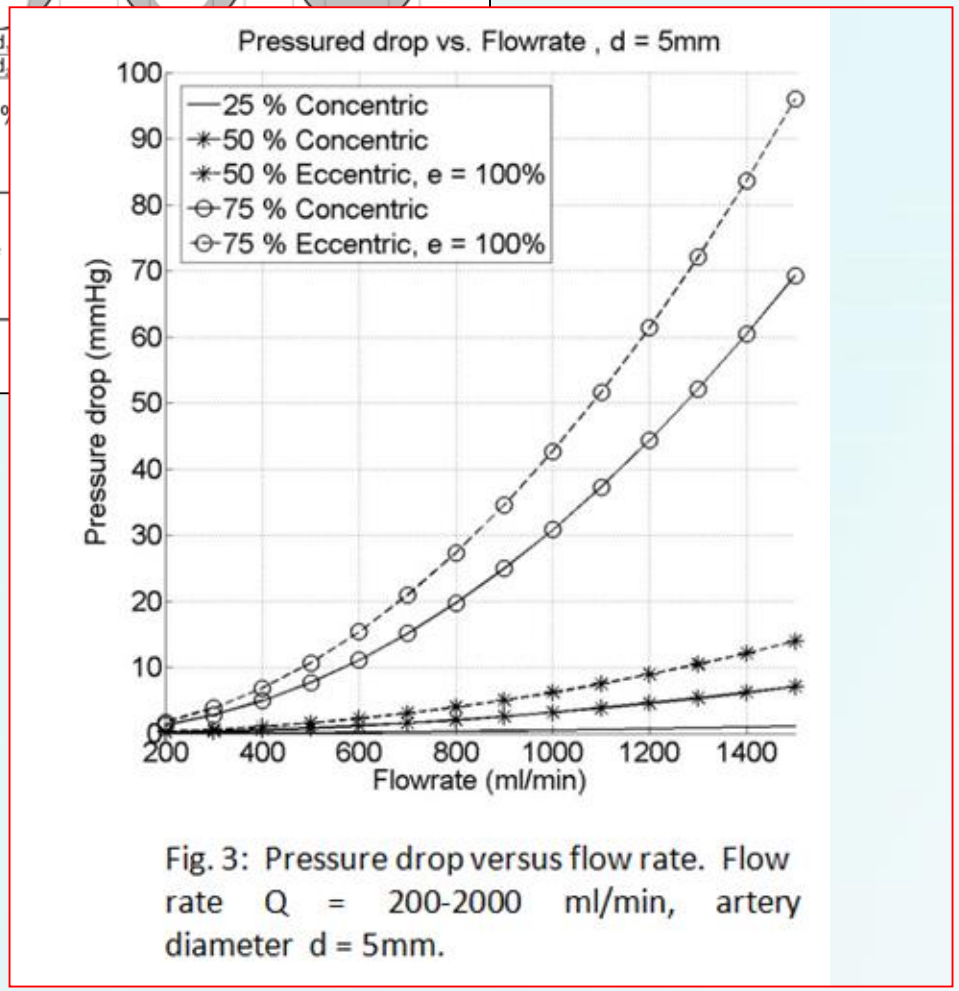
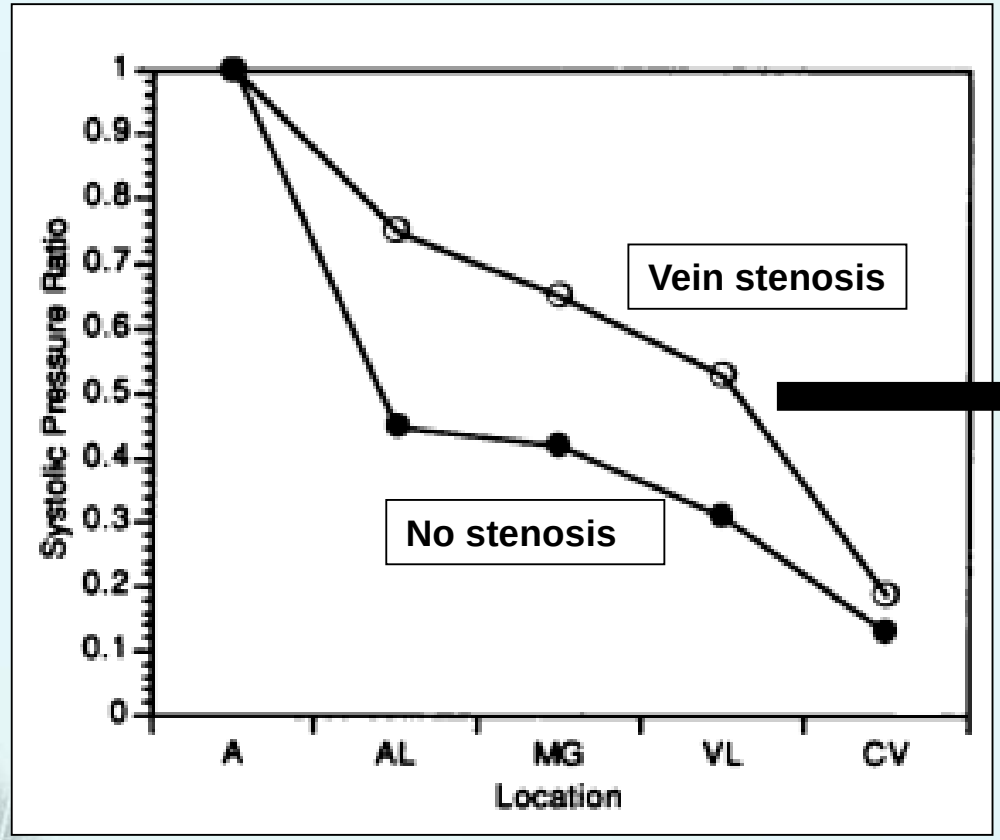




Fig. 3: Pressure drop versus flow rate. Flow rate Q = 200-2000 ml/min, artery diameter d = 5mm.

Novakova L et al.
Physiol. Res. 2015

# Pressure changes in AVG with and without stenosis

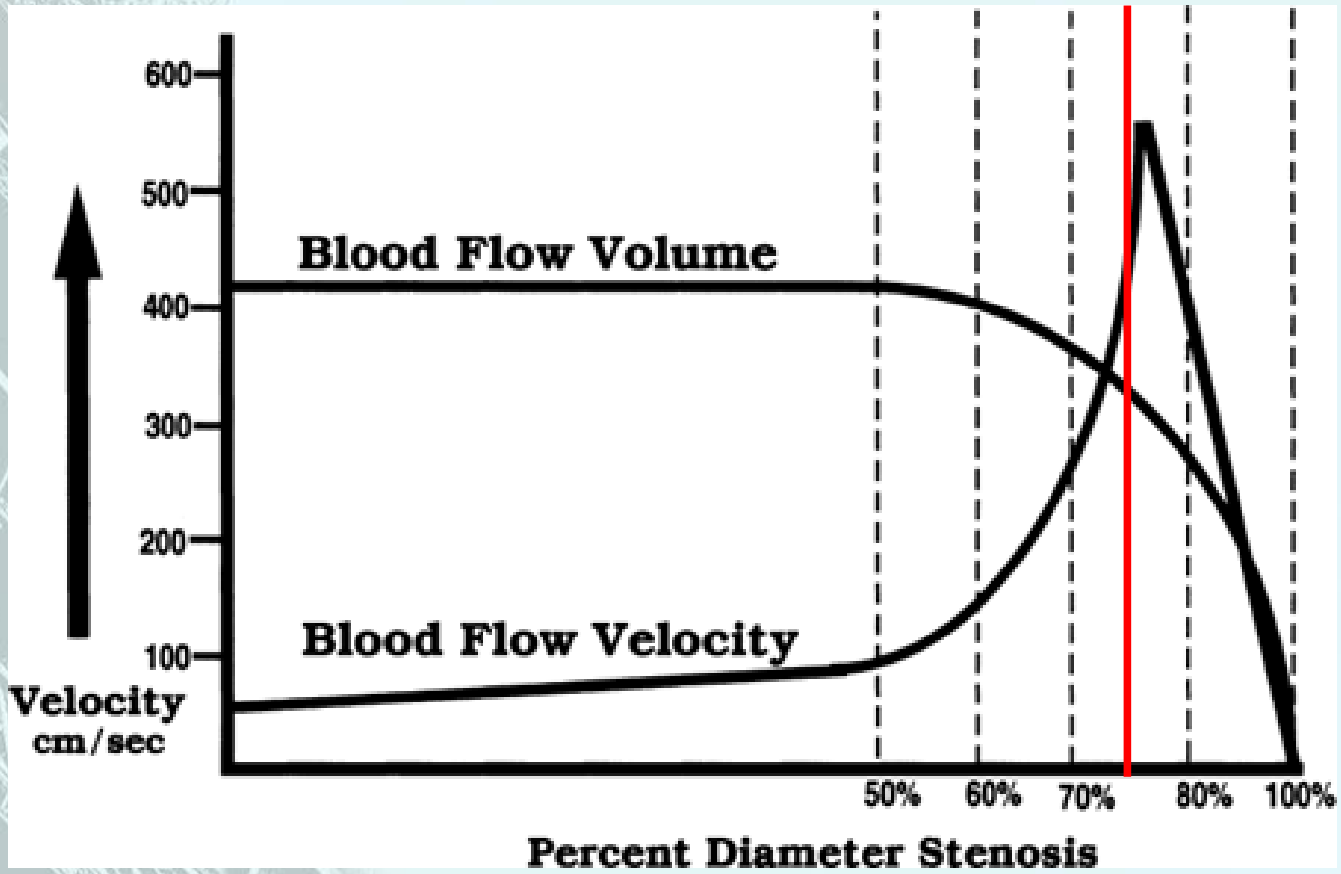



Hand edema
Prolonged bleeding

A: feeding artery, AL= arterial anastomosis, MG = mid-graft, VL = venous anastomosis,
CV = central vein

Sullivan KL et al. Radiology 1993;186(3):867-872

# Stenosis percentage and flow in arteries



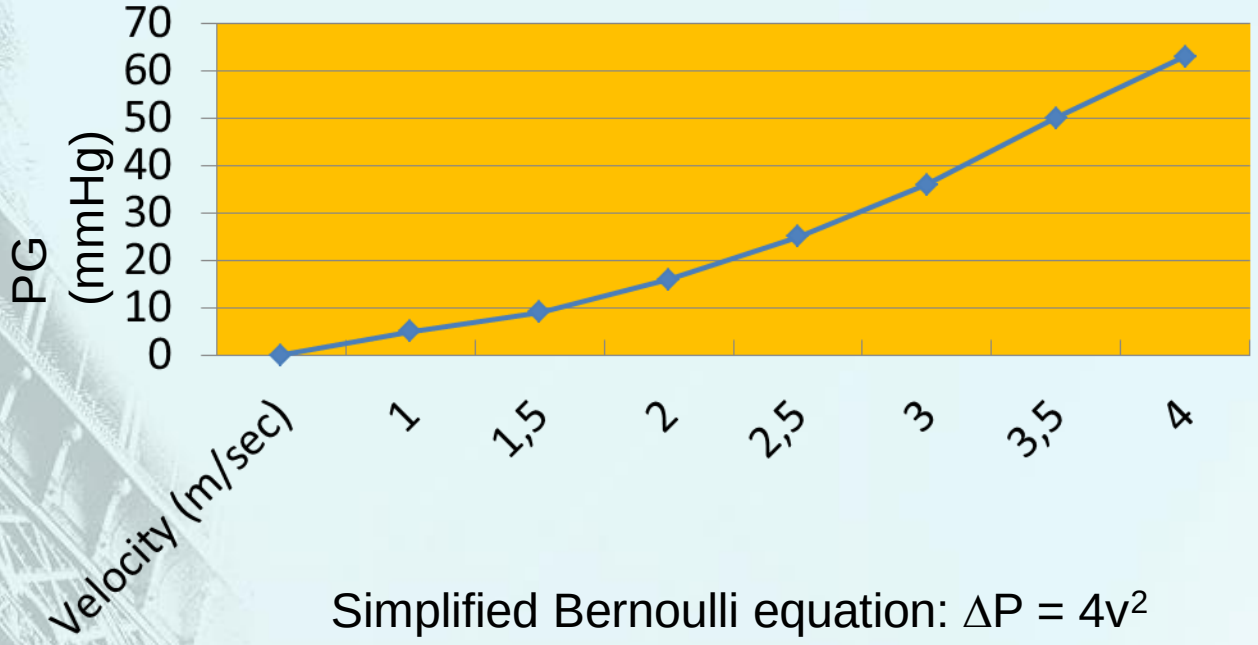



Core Curriculum, The: Ultrasound
1st Edition, 2001

# Flow acceleration ≈ pressure gradient



| Velocity (cm/sec) | Pressure gradient (mmHg) |
|---|---|
| 100 | 5 |
| 150 | 9 |
| 200 | 16 |
| 250 | 25 |
| 300 | 36 |
| 350 | 50 |
| 400 | 63 |

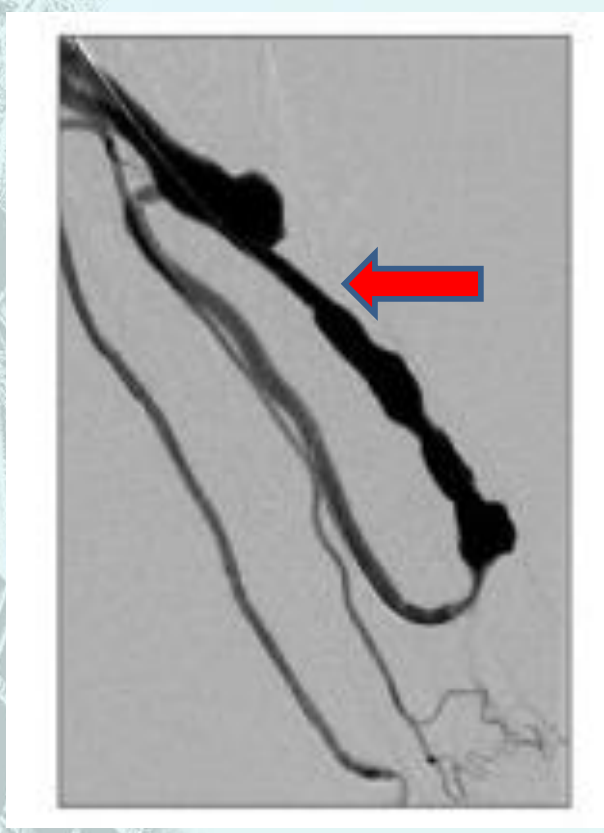



Simplified Bernoulli equation: $\Delta P = 4v^2$

# Stenosis percentage

- **Angiography**
- **B-mode ultrasonography**

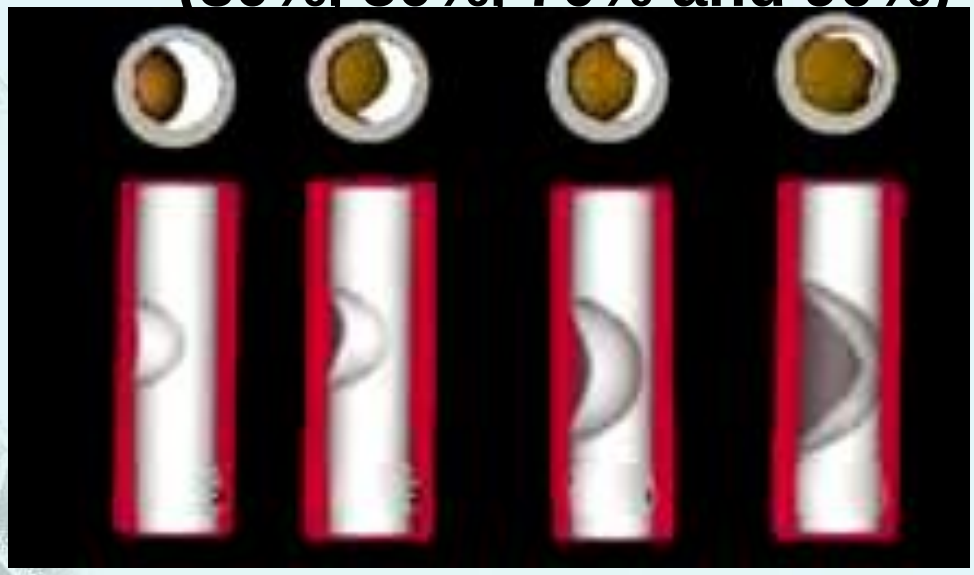
# Stenosis percentage



- Is it significant?
- Where is the reference/unaffected diameter?

# Angiography limitation

**Stenosis on transversal section (30%, 50%, 70% and 90%)**



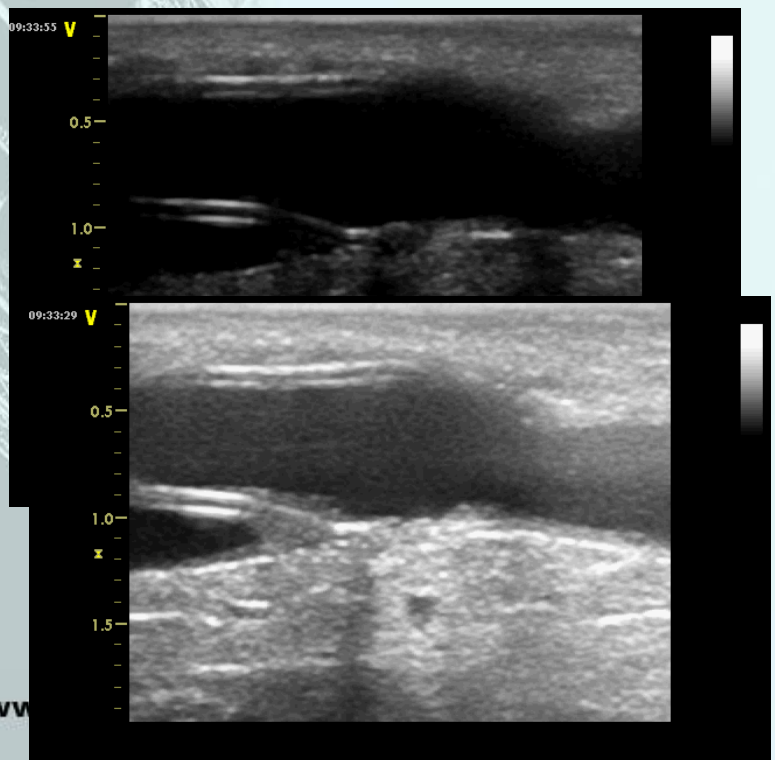
**„Luminogram“ according to the angle**

From: www.cardiologysite.com

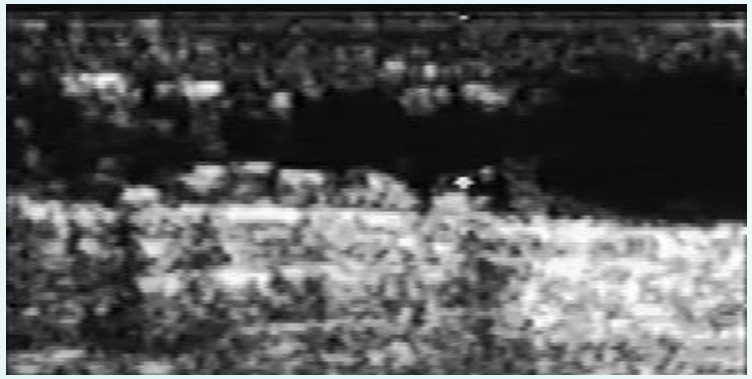
# Stenosis percentage by B-mode weakness



- Effect of ultrasound setting (gain, focus...)
- Effect of manual pressure on the vessel
- Shadows by calcified tissue
- Near-field artifact




Gain



**Always measure in longituinal section**

**> 50% diameter reduction as the only criterion in some trials**

# →FORGET PERCENTAGE OF STENOSIS

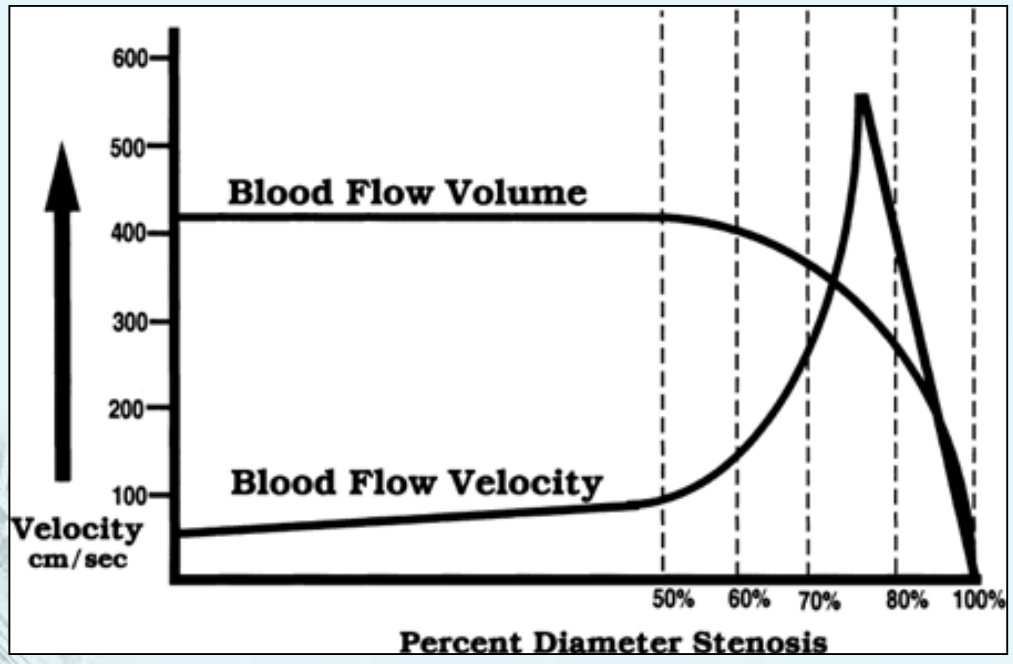
**MEASURE:**

- VELOCITY
- ACCESS FLOW
- RESIDUAL DIAMETER

DUPLEX DOPPLER ULTRASONOGRAPHY

# Stenosis: velocity criterion

- ≥ 2-3fold velocity increase = significant stenosis



# PSV above 400cm/sec in low Qa (600 ml/min or decrease by 25%)

- = significant stenosis
- can be used also in the arterial anastomosis

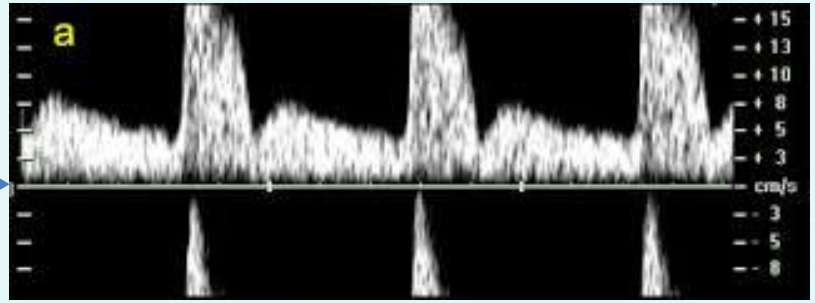
- According to some studies it can be used even without visualization

*Meola M: Ecografia Clinica e Colour-Doppler in Nefrologia, vol 1. In: Meola M (ed.) Lucca: Eureka, 2008: 263–312*

# Velocity measurement by USG

## Weakness

- Doppler angle (cosinus of) – use always the same, ideally 60°
- Aliasing limitation
- Manual pressure
- Acceleration in arches, irregularities



# Additional stenosis criteria

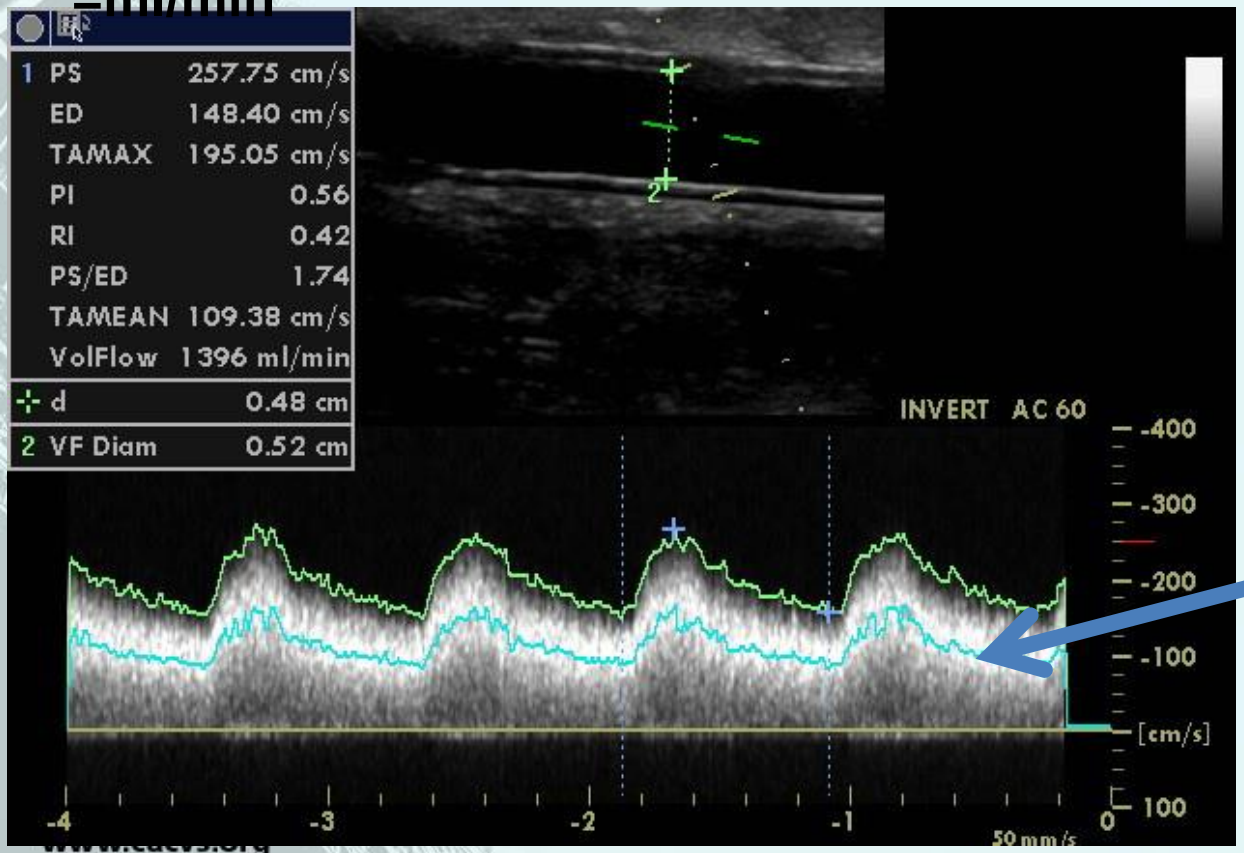
- Access flow volume
- Resistive index
- Residual diameter

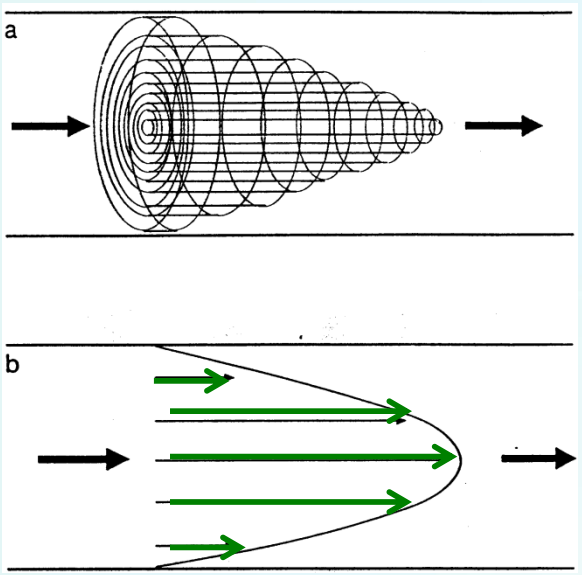
# Additional stenosis criteria

- **Access flow volume:**
  - decrease by 20-30% - corresponds to flow volume surveillance by dilution techniques
  - absolute value< 600 ml/min (< 500 in native AVFs)

# Flow volume calculation (Qa) = „function“ of the access

**Qa = π x $r^2$ x TAMEAN**
**= π x $cm^2$ x cm/sec x 60**
**=ml/min**



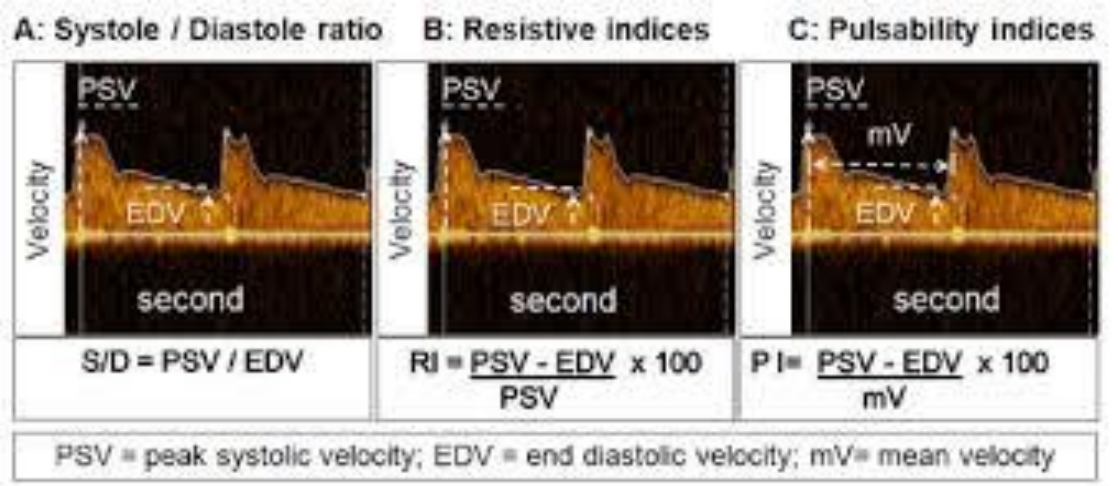




**TAMEAN = time-averaged mean velocity**

# Flow volume calculation = „function“ of the access

- Measure in a straight smooth segment, far from stenosis or arterial anastomosis
- AVF: measure in brachial artery
- AVG: measure in the graft

# Resistive index




Attempts to use RI for the detection of significant stenosis – conflicting results

↑ RI in the feeding artery = trombosis or stenosis close to the arterial anastomosis

Baird DE: J Ultrasound Med. 1994
Zachaeus M: Med Klin (Munich). 2005

Radiología. 2014;56(5):420–428

RADIOLOGÍA

www.elsevier.es/rx



ORIGINAL

**Value of doppler ultrasonography in the study of hemodialysis peripheral vascular access dysfunction**☆

T. Moreno Sánchez[a,b,*], C. Martín Hervás[c], E. Sola Martínez[a], F. Moreno Rodríguez[a,b]

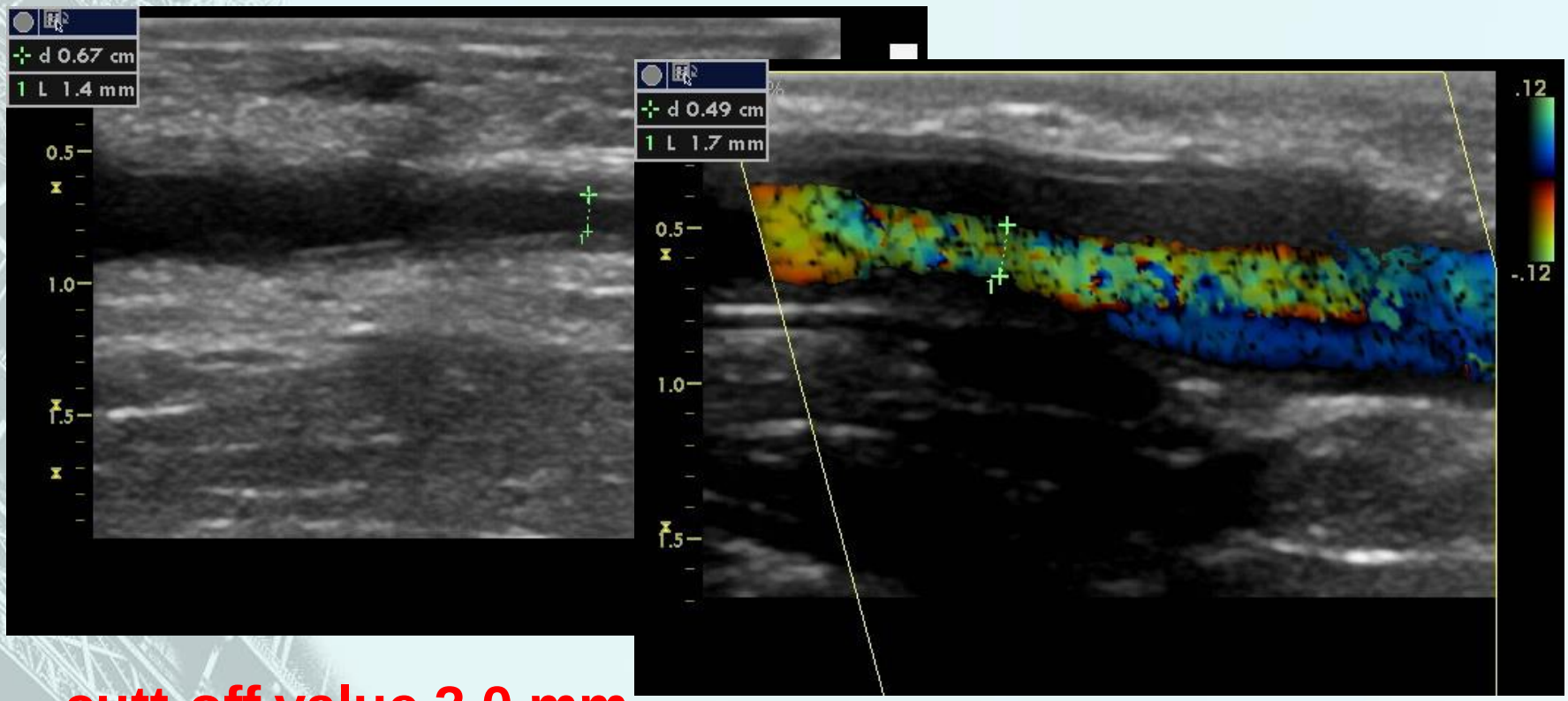
# Definition of stenosis:

- B-mode narrowing >50% + Aliasing + PSV >2

- Resistive index (RI) > 0,5 for diagnosis of significant stenoses:
  - Sensitivity 0.98
  - Specificity 0.74

**RI** = (peak systolic velocity - end diastolic velocity ) / peak systolic velocity

# Residual diameter by USG (B-mode + BFI)



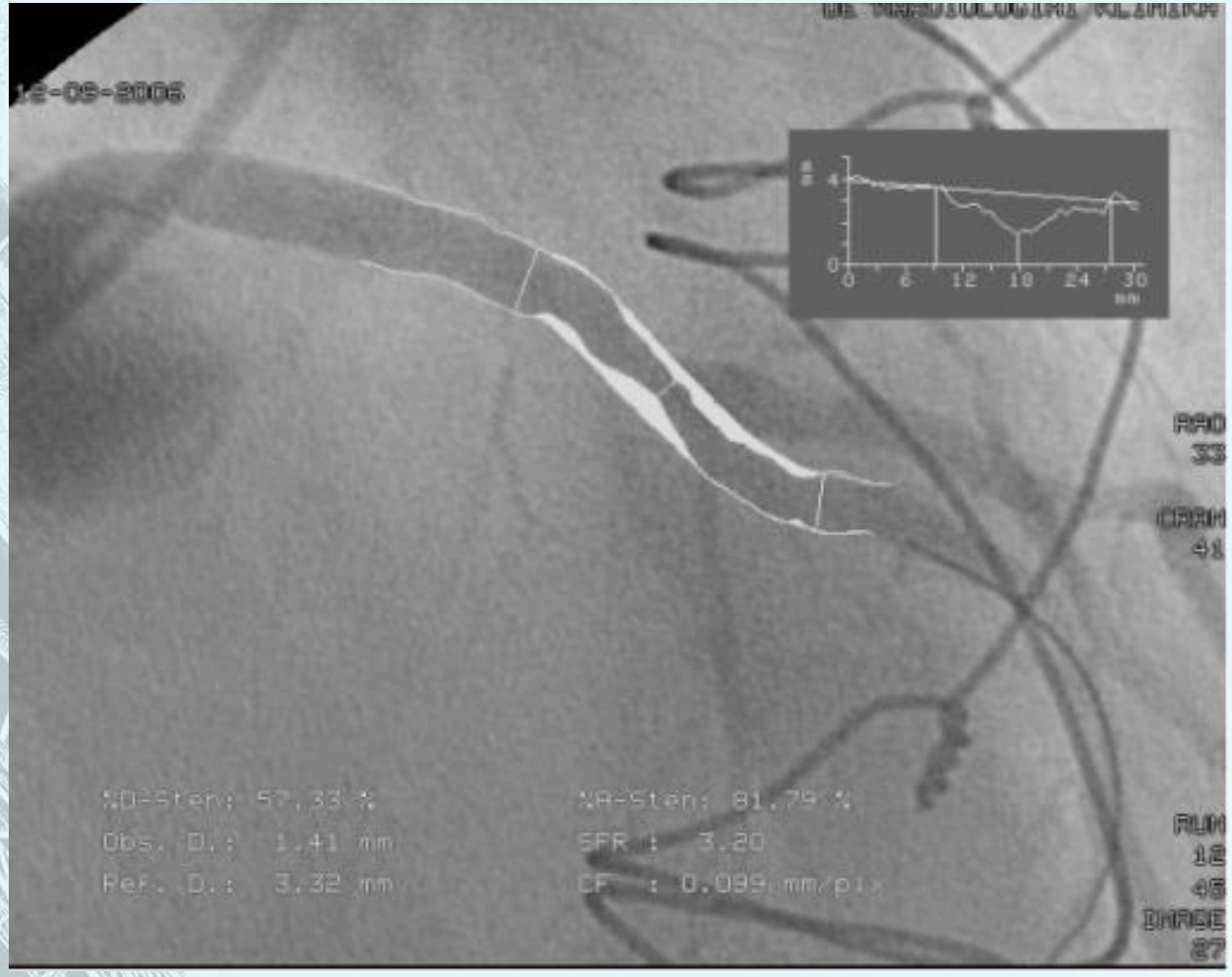

**cutt-off value 2.0 mm**

**BFI = blood flow imaging (GE ®)**

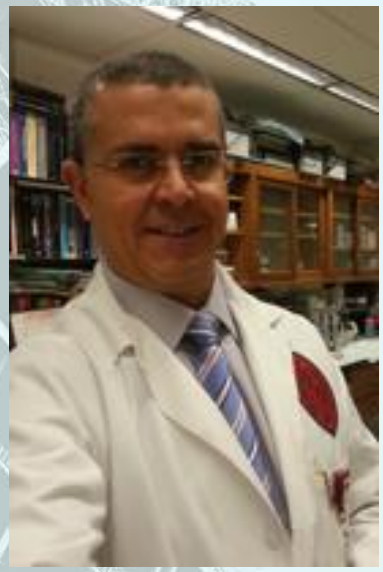
**High-frequency (>10MHz) probe!**

Kudlicka J. et al: More precise diagnosis of access stenosis: ultrasonography versus angiography. J Vasc Access. 2012;13(3):310-4

# Residual diameter by quantitative angiography



# Other factors influencing stenosis progression rate?



- Stenosis intima/media thickness
- Calcification score
- Shear stress
- Presence of diabetes mellitus....

# Significant vs. bordeline stenosis: complex DDU criteria

**B-mode lumen narrowing> 50%**

**+**

**> 2x peak systolic velocity increase**

+ 1 additional criterion:

a) resid. diameter<2.0mm

b) QB decrease > 25%

c) QB < 600 ml/min

**B-mode lumen narrowing> 50%**

**+**

**> 2x peak systolic velocity increase**

**No additional criterion**

Malik J: Kidney Int 2005, Tuka V: NDT 2009, Kudlicka J: J Vasc Access 2012

# Significant vs. bordeline stenosis: complex DDU criteria

| Significant stenosis | Borderine stenosis |
| --- | --- |
| ⇓ | ⇓ |
| PTA | Repeat ultrasound after 6-8 weeks |

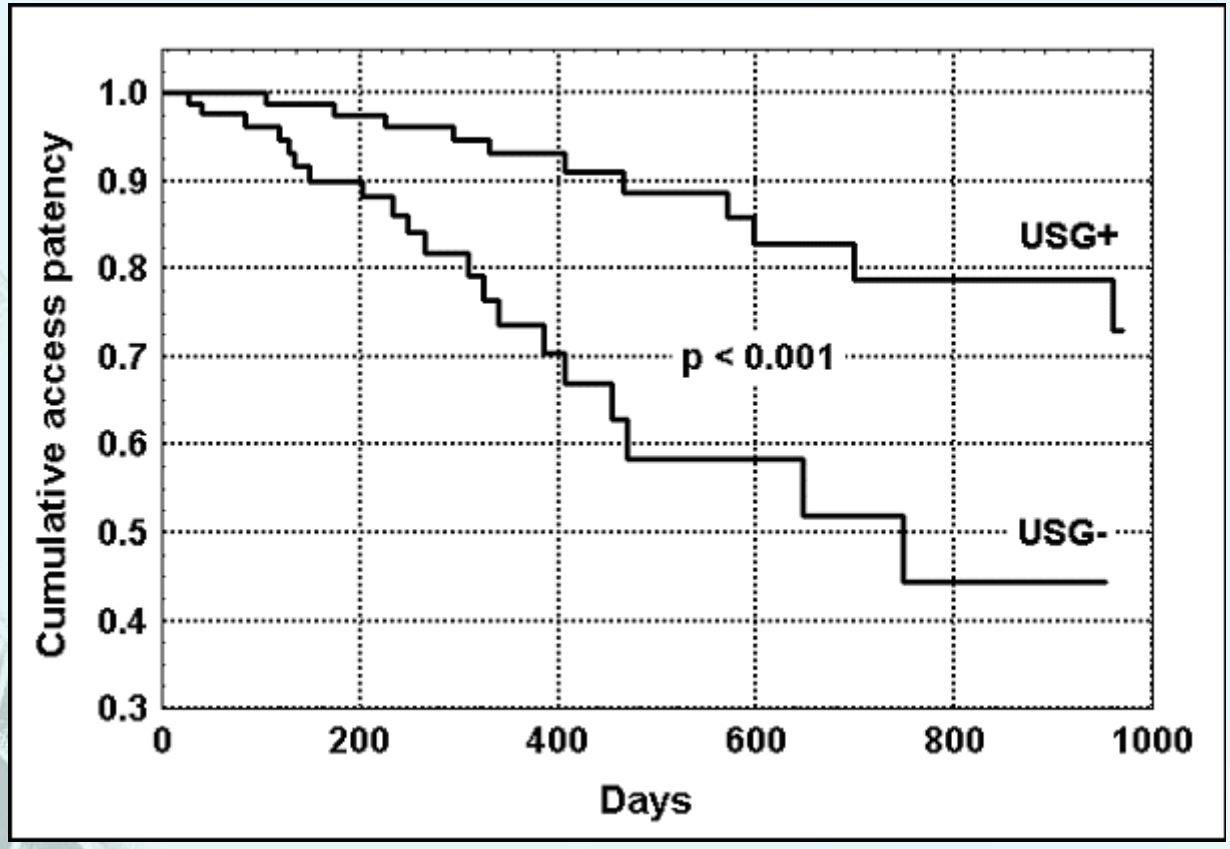
**PTA INJURES THE VESSEL WALL HEALING OF THE INJURY⇒RESTENOSIS**

**Restenosis development after PTA is faster than stenosis progression**

# Functional/practical approach to the PTA indication

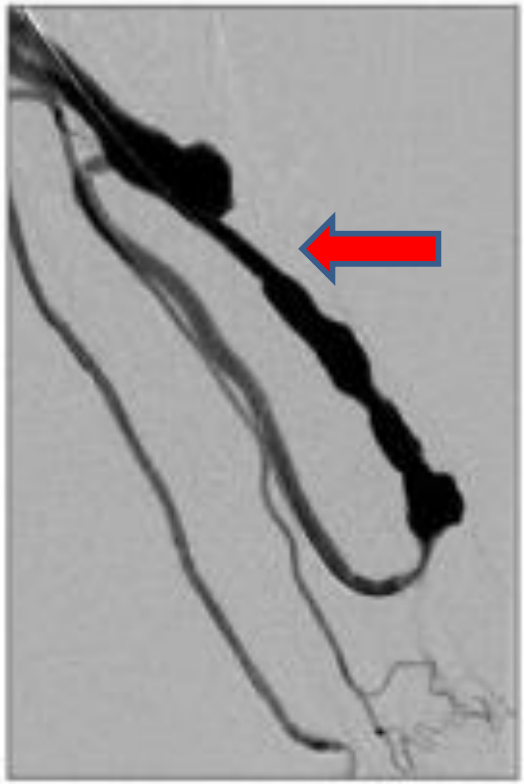
- Sy
- Is
- Pr ture?
- Pr hy
- La

# Effect of USG surveillance (every 3 months) on cumulative AVG patency




Malik et al. *Kidney Int* 2005

# Is this stenosis significant?



**NOT ENOUGH INFORMATION!!!**

**DO NOT FOLLOW „OCULO-STENOTIC REFLEX“**

**SAVE THE PATIENT AND MONEY**

# Conclusions (1)

- USG offers very precise and detailed description of both morphology and function of the access, even better than angiography (except for central veins)

- PTA = fast solution + long-term problem

# Conclusions (2)

- Strict criteria of stenosis significance, indicated to PTA, must be applied
- Do not bury surveillance too fast

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JANUARY 19-21 2017

*Thank you for your attention! malik.jan@vfn.cz*

10th Congress
of the Vascular Access Society

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www.vas2017.org

**SEE YOU IN LJUBLJANA!**
**ABSTRACT SUBMISSION +REDUCED FEE DEADLINES EXTENDED TILL JANUARY 31**