



## Peripheral Arterial Disease: US vs. CT or MRI

전북의대 영상학과

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### Introductions

- PAOD: Imaging modalities
    - ▶ Doppler US
    - ▶ CT
    - ▶ MRA
    - ▶ Angiography
  - Plan of treatment
    - ▶ Endovascular management
    - ▶ Surgical management
- Choice of imaging modalities**

### Contents

- PAOD
  - ▶ Findings of Doppler US
  - ▶ Comparison between US vs. CT or MRI

### US Doppler Imaging for Medical Applications

- US
  - ▶ Non-invasive, real time: 편리하고 저비용의 효과적인 진단 수단
- Spectral Doppler
  - ▶ 혈류 정보 계측
  - ▶ 혈류의 시간에 따른 변화
  - ▶ 정량적 계측: 속도, 방향 등
  - ▶ Doppler spectrum과 audio로 표현
- Color Doppler
  - ▶ 평면의 혈류를 단층영상으로 표현
  - ▶ 정상적 영상화
  - ▶ 평균속도, 방향, Turbulence, power 등을 색상으로 표현

### Doppler US: Role - PAOD

- Stenosis
  - ▶ Location
  - ▶ Multiple segment 유무
- Obstruction: atherosclerosis or acute emboli
  - ▶ Location
  - ▶ Collateral vessels or run-off vessels

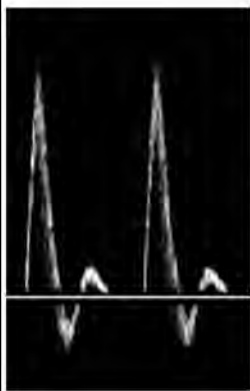
## PAOD

- Location
  - Bifurcation area
  - Distal SFA and proximal PA
  - Diabetics: tibial and peroneal arteries
- Doppler US
  - Spectrum sampled above or distal to the site of an arterial lesions

## Normal Artery: Doppler US

- Relatively uniform
- Same speed and direction
- A narrow band of frequencies
- A clear area under the systolic peak

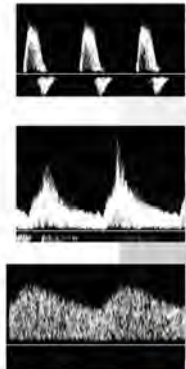
## Normal spectral waveform: Triphasic



- I. Cardiac systole: initial high-velocity forward flow phase
- II. High impedance of distal muscle artery: Reversal of flow in early diastole
- III. Proximal arterial compliance: Third forward component

## Additional spectral waveform

- Biphasic
  - Sharp systolic forward and reverse flow during diastole
  - high resistance and low velocity
- Sharp monophasic
- Poor monophasic
  - low resistance and low velocity



## Value of the duplex scanning waveform at the CFA for diagnosing obstructive aortoiliac disease

*J Vasc Surg 2005;42:236-242*

- 191 pts. (381 aortoiliac segments)
  - Significant aortoiliac disease
  - Detecting > 50% obstructive disease of the aortoiliac segment

CFA duplex	No lesions	Obstruction	Total
Triphasic	156	51	207
Biphasic	42	12	54
Sharp monophasic	19	4	23
Poor monophasic	7	84	91
None			
Total			

**Poor monophasic duplex waveform: accurate marker of aortoiliac obstructive disease**

## High resistive pattern without early diastolic reversal flow

*J Vasc Surg 2005;42:236-242*

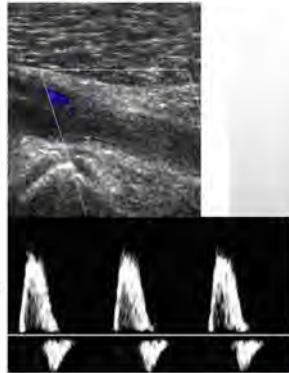
- Sharp monophasic
  - Distal obstruction
  - 17/23 (73.9%)



## Biphasic: low velocity and high resistance

- Acute embolic events
  - No distal blood flow

- Nondiagnostic findings
  - Clinical symptoms



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## Long-term arterial occlusions

- Development of significant collaterals
- Proximal artery waveforms
  - Normal
- Distal artery waveforms
  - Monophasic patterns – low resistance component

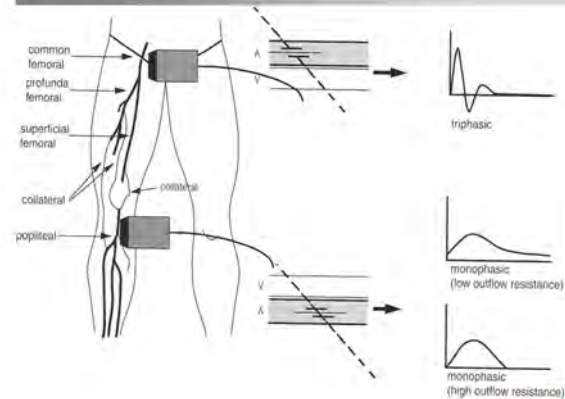
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## Monophasic Waveform

- Proximal arterial disease
- Proximal to an occlusion
  - sharp monophasic, biphasic: High resistance, low velocity
  - Triphasic: prominent collateral vessels
- Distal to an occlusion – poor monophasic
  - Low resistance, low velocity

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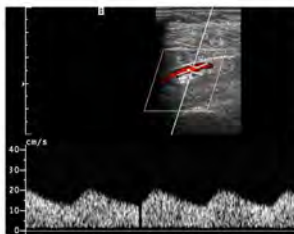
## Monophasic waveform



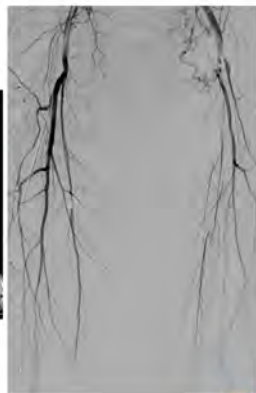
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## Complete obstruction

66/M. left SFA obstruction

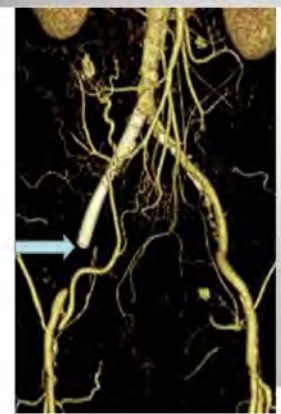
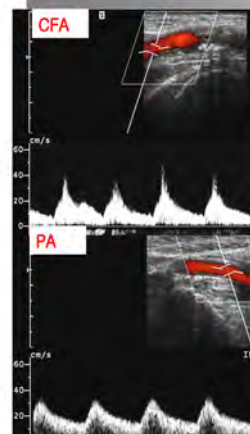


Left PA Doppler US



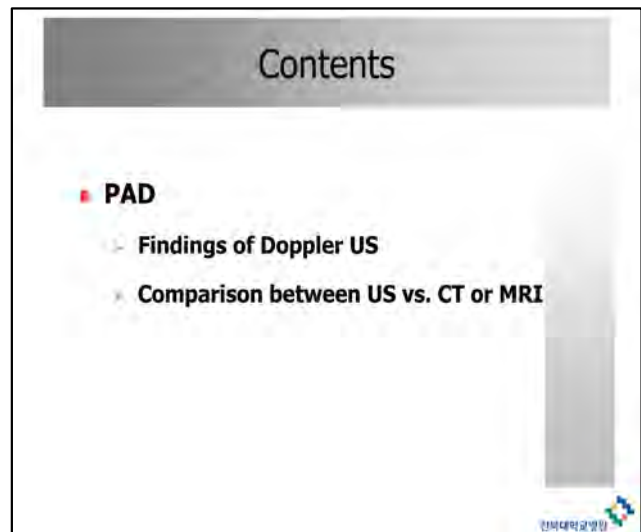
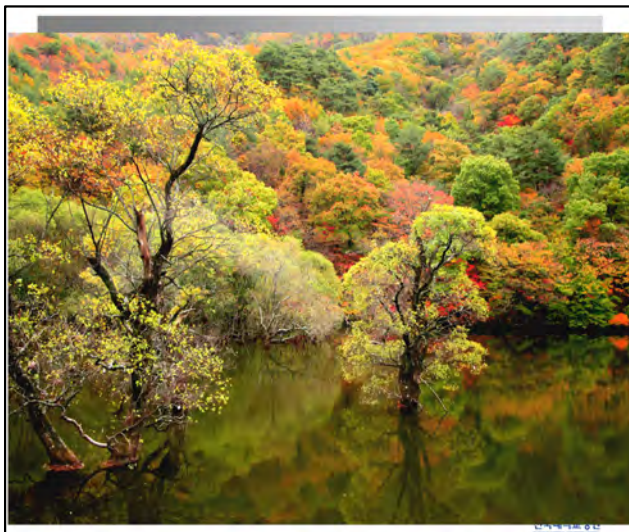
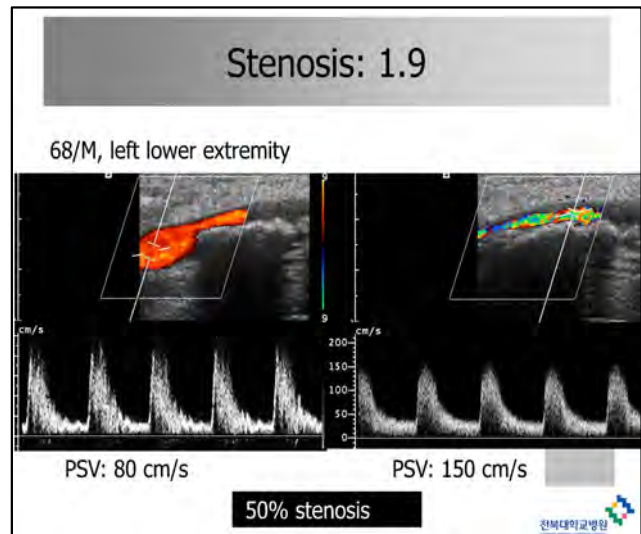
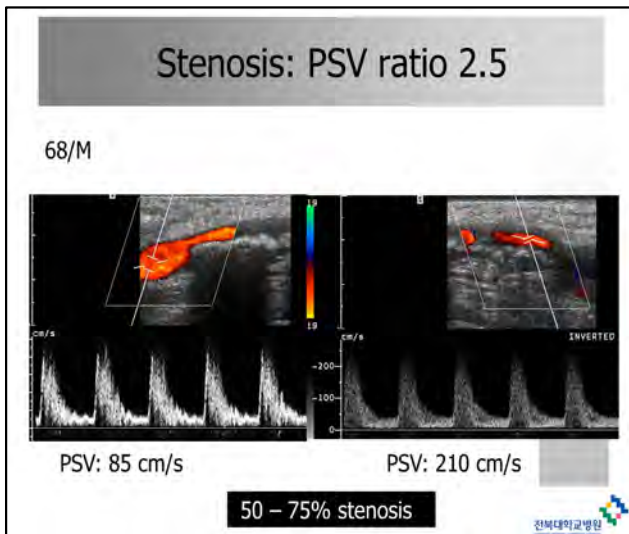
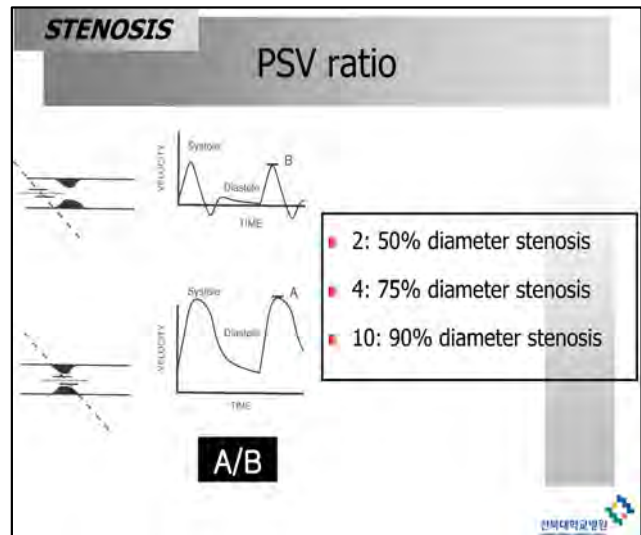
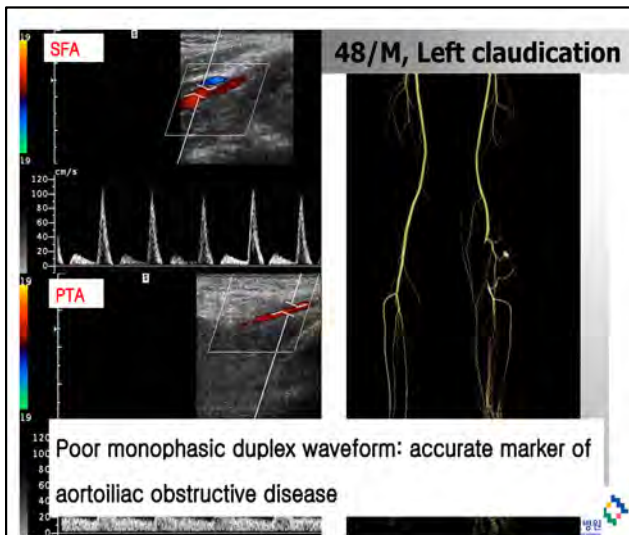
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## Obstruction



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## Comparison of doppler US, MRA, and angiography

*Semin Vasc Surg 2007;20:15-28*

- 64-lower extremity: Angiography, Doppler US, MRA
  - Arterial segments: classification
  - Mild disease (<50%), moderate disease (50 – 70%), severe disease (70 – 99%), occlusions

## Comparison of doppler US, MRA, and angiography

*Semin Vasc Surg 2007;20:15-28*

	sensitivity (%)	specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
MRA					
aortoiliac	100	81	23	100	82
FP	86	53	82	60	74
Tibial	61	51	30	79	54
Doppler US					
aortoiliac	100	96	67	100	96
FP	97	94	97	94	96
Tibial	81	100	100	94	95

Comparison MRA or Doppler US versus angiography

## The role of Duplex scanning in the selection of patients with critical lower-limb ischemia for infrainguinal percutaneous transluminal angioplasty

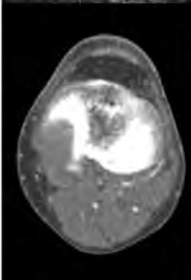
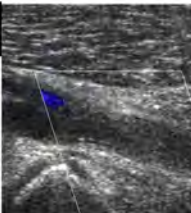
*Cardiovasc Intervent Radiol 2001;24:229-232*

- Accuracy of duplex scanning
  - femoropopliteal and crural lesions : 85%
- Sensitivity
  - popliteal area: 49%
  - crural area : 38%
  - SFA lesions : 80%
- Multiple distal lesions: relative low accuracy
  - 39% of patients with PTA: misdiagnosis one of the multiple lesions

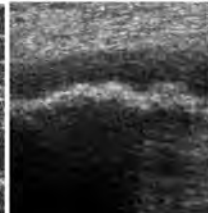
## Advantage of Doppler US

- Vessels with very low flow (<20cm/s)
- Identification of the softest portion of the vessel wall
  - anastomotic site of choice
- Assess the actual disease of the vessel
  - thickness of the wall
  - differentiate between an isolated chronic SFA occlusion and acute embolism with little underlying disease or acute thrombosis with severe atherosclerotic disease
  - ulcerated and irregular plaques
- Hemodynamic information
  - volume flow and velocity measurements

47/M. PA  
Acute thrombus



77/M. CFA  
Atherosclerosis



## Limitations of Doppler US

- Calcified vessel walls
- Skin-quality problems
  - severe dermatitis, open ulcers, heavy scarring, lymphedema, hyperkeratosis...
- Iliac artery
  - tortuosity, recent abdominal surgery, ascites, morbid obesity, gas interposition....

Increase gain, persistence, sensitivity power Doppler

Spectral waveforms: CFA

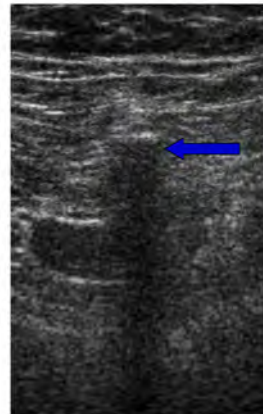


## Limitations of Doppler US

- Incomplete visualization of the crural and pedal vessels
  - for bypass surgery or flap
- Multiple distal lesions
  - high rate of misdiagnosis
- Operator dependent
  - communication between vascular surgeons or interventional radiologists and Doppler operators
- Direct evidence of cystic adventitial or popliteal entrapment syndrome

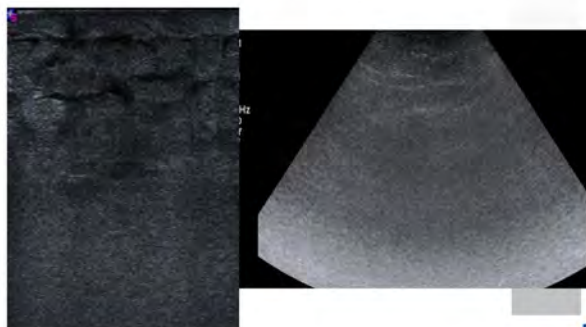


## Calcified vessels



## Skin quality problem

- 62/F, Lymphoma and obesity



## Intraarterial MR angiography and DSA in patients with PAOD

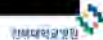
*Radiology 2006;239:901-908*

- 20 pts.: symptomatic PAOD
  - prospective comparison: MR angiography and DSA
- Sensitivity, specificity, accuracy
  - Femoropopliteal artery: 92%, 94%, 93%
  - Infrapopliteal artery: 93%, 71%, 86%
- Venous contamination: 12%



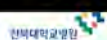
## Limitations of MRA

- Patient
  - elderly pts. with multiple comorbid conditions
  - sedation
- Assess the degree of disease and the degree of patency
- Low-flow/signal dropout and venous contamination
- Unaffected by the presence of vascular calcification

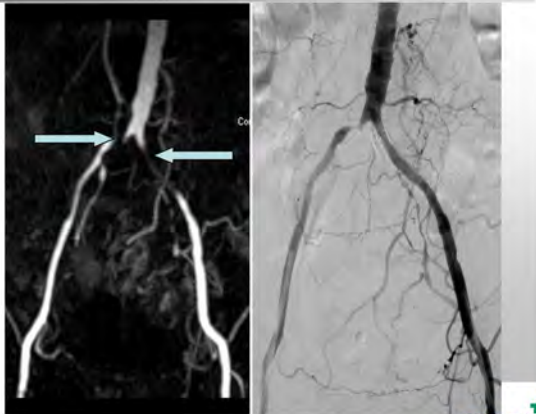


## Venous contamination

- External venous compressions
  - Thigh or proximal calf
- Combination of dedicated calf MR angiography and standard bolus-chase MR angiography
  - Same imaging session
- Time-resolved MR angiography



## Artifact



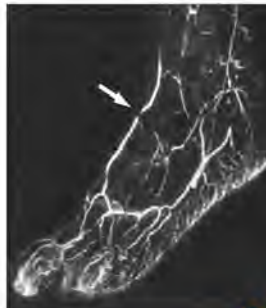
## Role of Doppler US in renal and diabetic patients

- CIN after angiography
  - diabetic patients: 10%
  - chronic renal insufficiency: 12%
- Role of duplex US
  - Some studies: excellent correlation between doppler US and angiography
  - However, most pts. – preoperative angiography
  - contrast-enhanced MRA

## Diabetes: MR angiography

*AJR 2000;174:171-178*  
*Radiology;242:610-620*

- MR angiography: pedal or calf vessels
  - sensitivity: 72 – 92%
  - specificity: 90%
- Change of treatment plan: for bypass graft
  - 38%: MR angiography >> DSA



## Comparison of CTA to angiography

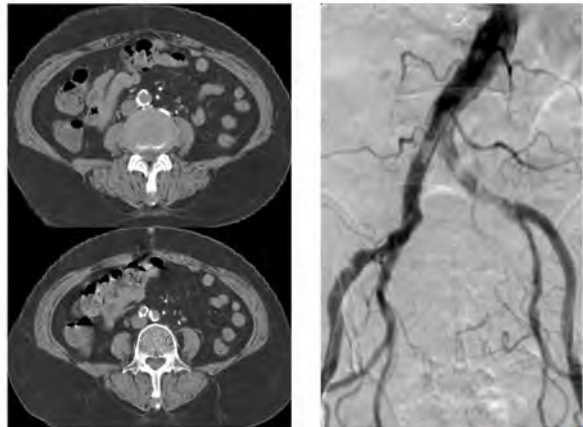
- CTA
  - increased volumetric coverage
  - improved z-axis resolution
  - better separation of different vascular phase and isotropic voxels
  - single-image acquisition
  - postprocedure imaging processing and three-dimensional image to any angle

**Comparison study between CTA and angiography: sensitivity and specificity >93 – 95%**

## Advantages of CTA

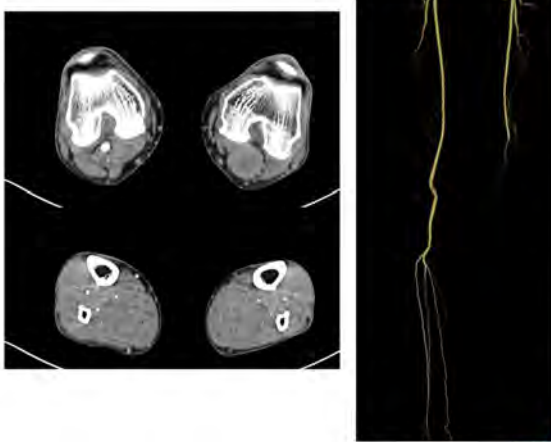
- Presence or absence of significant obstruction
  - calcified plaque or thrombus
- Site and anatomical extent of obstruction
- Status of collateral flow and distal vasculature for planning treatment
- Monitor the results of therapy and disease progression

## 71/F, Obstruction of abdominal aorta and CIA





56/M, Popliteal artery pseudoaneurysm with thrombus



## Comparison of CTA to angiography

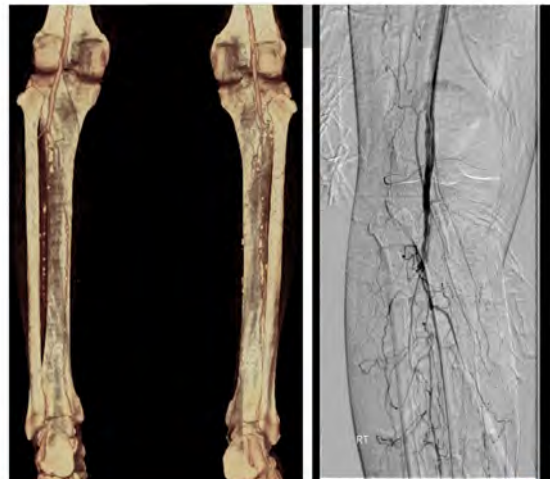
*Semin Vasc Surg 2007;20:15-28*

■ 36 pts.

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Aortoiliac		100			100
FA	100	25	80		81
Below knee	75	50	63	44	59

## Disadvantages of CTA

- Heavy calcification
  - × partial volume and 'blooming' artifact
  - × overestimation of stenosis in small caliber vessels beyond the level of the knee
- Radiation dose
- Absence of any hemodynamic assessment
- Interventional radiologists and vascular surgeons
  - To plan the most appropriate therapeutic method
  - Screening modality for initial assessment of vascular disease



## Summary

### US vs CT or MRI: PAOD

- Aortoiliac, femoropopliteal
  - × Similar sensitivity and specificity
- Below knee
  - × US or CT: limitation
  - × MRA: relatively high sensitivity excluded venous contamination
- Operator dependent: US – communications
- Calcified vessels: MRA
- Characteristics of intraluminal lesions: US or CT

## Summary

### CT and MRA

- Recently, increased role of diagnosis of PAOD
  - × Non-operator dependent
  - × Evaluation of long segment
  - × Rapid development of 3D-postprocessing
  - × Many patients: for treatment plan
- Many institute: replaced with Doppler US



## Summary

### Doppler US

- Spectral Doppler US
  - Monophasic waveforms: accurate parameter of proximal arterial obstructive disease
- PSV ratio ↑
- High sensitivity and specificity: diagnosis of PAOD

■ Screen test and follow up: role

■ Only Doppler US: treatment plan?

### PAOD: Doppler US, CTA, MRA

- Communication?
- Symptoms of patients
- Treatment plan?
- Cost?
- Clinicians , radiologists, interventional radiologists, vascular surgeons