ECHOCOLODOPPLER LESSONS

ULTRASOUND IN PERIPHERAL ARTERIAL ATHEROSCLEROTIC DISEASE

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Ultrasound in peripheral arterial atherosclerotic disease

INTRODUCTION

In presence of peripheral arterial atherosclerotic disease, it is necessary to detect and describe the stenosis, the occlusions and the aneurysms. In the hemodynamic stenosis, although duplex ultrasound includes images, the primary parameter is the peak systolic velocity: a high-velocity systolic and diastolic signal is revealed over the stenotic segment.

The peripheral arterial occlusion is characterized by the absence of the color and of the spectral Doppler waveform within the arterial segment occluded. The waveform recorded distal to the occlusion is monophasic, in the absence of reversed component.

The ultrasound imaging is the initial non-invasive diagnostic modality used to study the peripheral artery aneurysms: the echocolor Doppler may demonstrate swirling flow within the aneurysm or no color flow if it is completely occluded.

In this lesson the echocolor Doppler characteristics of the peripheral arterial atherosclerotic disease are presented.
COLORDUPLEX ULTRASOUND OF THE LOWER-EXTREMITY ARTERIES
CAROTID IMT AND CAROTID AND/OR ILIOFEMORAL PLAQUES

- arterial plaques may constitute a better marker of the presence of CVD than CCA-IMT.
- comparisons according to 10-year Framingham equations did not show statistical significance, but both measures seemed to be highly predictive and possibly complementary.
- prospective studies are needed to confirm these findings.

CAROTID AND LOWER LIMB ATHEROSCLEROTIC PLAQUES IN TYPE 2 DIABETES MELLITUS

- Carotid plaques might underestimate generalized plaques in inpatients with type 2 diabetes, as shown by its significantly lower prevalence compared with that of the lower extremity arteries.

- A combined carotid and lower limb ultrasound examination can improve the detection of atherosclerotic lesions in inpatients with type 2 diabetes.

Li LX et al. Comparison of carotid and lower limb atherosclerotic lesions in both previously known and newly diagnosed type 2 diabetes mellitus. J Diabetes Investig. 2014
1. B-mode shows the structure of blood vessels and color Doppler shows different rates of blood flow in different colors
2. Pulsed Doppler shows the movement of red blood cells through the vessels
3. EcocolorDoppler produces color coded images to show the structure of the vessel as well as the speed and direction of blood flow
Peripheral arterial atherosclerotic disease

PERIPHERAL ARTERIES

1. detection of hemodynamically significant stenoses
2. peripheral artery aneurysms
3. monitoring of sites of previous surgical interventions/percutaneous interventions
Peripheral arterial atherosclerotic disease

PERIPHERAL ARTERIES

1. Detection of hemodynamically significant stenoses

2. Peripheral artery aneurysms

3. Monitoring of sites of previous surgical interventions/percutaneous interventions
Peripheral arterial atherosclerotic disease

Lower limb arterial stenosis

Most common sites

- aorto-iliac: 25%
- femoro-popliteal: 65%
- infra-popliteal: 10%

Kaplan–Meier Survival Curves Based on Mortality from All Causes among Normal Subjects and Subjects with Symptomatic or Asymptomatic Large-Vessel Peripheral Arterial Disease

Mortality over a period of 10 years in patients with peripheral arterial disease

Management of peripheral arterial disease in primary care

- Survival
- Myocardial infarction
- Intervention
- Amputation

BMJ 2003;326:584-588
peripheral arterial stenosis

US criteria

LOWER LIMB ARTERIAL STENOSIS

- the full length of the arterial segment of interest should be evaluated with color Doppler US
- a spectral Doppler waveform with velocity measurements upstream and downstream of any stenosis should be documented
- the location and the length of any diseased or nonvisualized segment should also be documented
- every attempt should be made to acquire the Doppler angle (between the Doppler insonation beam and the direction of moving blood) less than or equal to 60°
Peripheral arterial stenosis

**US criteria**

### DUPLEX CRITERIA FOR EVALUATION OF PERIPHERAL ARTERIAL HEMODYNAMIC STENOSIS

1) **ELEVATED VELOCITIES:**
   - Diagnostic criteria use PSV (> 125 cm/s): ratios of distal/proximal PSV (2:1)
   - Elevated end-diastolic velocity

2) **DIAMETER REDUCTION:**
   - Transverse or longitudinal measurements indicating reduction in luminal diameter (are supportive, not diagnostic)

3) **SPECTRAL BROADENING OR COLOR MOSAIC PATTERN:**
   - Presence of turbulent
   - Aliasing of color Doppler signal

4) **COLOR BRUIT, COLOR PERSISTENCE:**
   - Color bruit, providing evidence of vibration in the tissue surrounding arterial narrowing
Peripheral arterial stenosis

US Criteria

Dublex Criteria for Evaluation of Peripheral Arterial Hemodynamic Stenosis

1) Elevated Velocities:
   - Diagnostic criteria use PSV (> 125 cm/s): ratios of distal/proximal PSV (2:1)
   - Elevated end-diastolic velocity

2) Diameter Reduction:
   - Transverse or longitudinal measurements indicating reduction in luminal diameter (are supportive, not diagnostic)

3) Spectral Broadening or Color Mosaic Pattern:
   - Presence of turbulent
   - Aliasing of color Doppler signal

4) Color Bruit, Color Persistence:
   - Color bruit, providing evidence of vibration in the tissue surrounding arterial narrowing
Peripheral arterial stenosis

US criteria

Peripheral Arterial Stenosis
primary parameter: velocity of blood flow

- Although duplex US includes images, the primary parameter for the study of a peripheral arterial stenosis is peak systolic velocity.
- the velocity increases with the increase of the degree of stenosis (b)
- a reduction of the diameter more than 90-95% (c) involves a reduction of the velocity
peripheral arterial stenosis

**US criteria**

**VELOCITY CRITERIA FOR EVALUATION OF PERIPHERAL ARTERIAL HEMODYNAMIC STENOSIS**

**FLOW WAVEFORMS MODIFICATIONS**

a. **upstream:** high-resistance waveforms are present

b. **over the stenotic segment:** a high-frequency signal is revealed during systole and diastole (the narrowed segment increases the velocity of flow). The criteria commonly used to diagnose a stenosis greater than 50% diameter is: PSV ratio within or beyond the stenosis compared with the adjacent upstream segment greater than 2

c. **downstream:** waveforms recorded just distal to the stenosis are monophasic in the absence of reversed component
DUPLEx US OF LOWER EXTREMITY CAN BE USED TO DIAGNOSE THE LOCATION AND DEGREE OF STENOsis

a) upstream: high-resistance waveforms are present (PSV= 95 cm/s)
Peripheral arterial stenosis

**US criteria**

- **a)** Upstream: high-resistance waveforms are present (PSV = 95 cm/s)
- **b)** Directly over the stenotic segment, a high-frequency signal is revealed, because the narrowed segment increases the velocity of flow (PSV = 267 cm/s). PSV ratio distal/proximal > 2

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**DUPLEx US of Lower Extremity can be used to Diagnose the Location and Degree of Stenosis**

- **a)** Upstream: high-resistance waveforms are present (PSV = 95 cm/s)
- **b)** Directly over the stenotic segment, a high-frequency signal is revealed, because the narrowed segment increases the velocity of flow (PSV = 267 cm/s). PSV ratio distal/proximal > 2
peripheral arterial stenosis

**US criteria**

b) high velocity flow = 2.67 m/s

a) upstream: high-resistance waveforms are present

b) monophasic waveform recorded just distal to the stenosis

**DUPLEX US OF LOWER EXTREMITY CAN BE USED TO DIAGNOSE THE LOCATION AND DEGREE OF STENOSIS**

a) upstream: high-resistance waveforms are present (PSV = 95 cm/s)
b) directly over the stenotic segment, a high-frequency signal is revealed, because the narrowed segment increases the velocity of flow (PSV = 267 cm/s). PSV ratio distal/proximal > 2
c) download: waveforms recorded just distal to the stenosis are monophasic in the absence of reversed component
peripheral arterial stenosis

US criteria

Diagnostic criteria for peripheral arterial stenosis

1. PSV on the stenosis/proximal \( \text{PSV} > 2 \) \( \rightarrow \) diameter reduction \( > 50\% \)
2. PSV on the stenosis/proximal \( \text{PSV} > 4 \) \( \rightarrow \) suggests diameter reduction \( > 75\% \)
3. PSV on the stenosis/proximal \( \text{PSV} > 7 \) \( \rightarrow \) suggests diameter reduction \( > 90\% \)

SUPERFICIAL FEMORAL STENOSIS

a) proximal \( \text{PSV} = 21 \text{ cm/sec.}; \) b) over the stenotic segment: \( \text{PSV} = 276 \text{ cm/s.}; \) c) distal \( \text{PSV} = 15 \text{ cm/sec.} \)

\( \text{PSV ratio (on the stenosis/proximal)} > 10 \) suggests diameter reduction \( > 90\% \)
peripheral arterial stenosis

US criteria

b) monophasic waveform recorded just distal to the stenosis

a) superf. fem. art. stenosis:
   peak systolic velocity
   \[ = 3.82 \, \text{m/s} \]

DUPLEX US OF LOWER EXTREMITY CAN BE USED TO DIAGNOSE
THE LOCATION AND DEGREE OF STENOSIS

a) directly over the stenotic segment: high-frequency signal is revealed during systole and diastole, because the narrowed segment increases the velocity of flow

b) download: waveforms recorded just distal to the stenosis are monophasic in the absence of reversed component
peripheral arterial stenosis

US criteria

DUPLEX CRITERIA FOR EVALUATION OF PERIPHERAL ARTERIAL HEMODYNAMIC STENOSIS

1) ELEVATED VELOCITIES:
- diagnostic criteria use PSV (> 125 cm/s): ratios of distal/proximal PSV (2:1)
- elevated end-diastolic velocity

2) DIAMETER REDUCTION:
- transverse or longitudinal measurements indicating reduction in luminal diameter (are supportive, not diagnostic)

3) SPECTRAL BROADENING OR COLOR MOSAIC PATTERN:
- presence of turbulent
- aliasing of color Doppler signal

4) COLOR BRUIT, COLOR PERSISTENCE:
- color bruit, providing evidence of vibration in the tissue surrounding arterial narrowing
COMMON FEMORAL ARTERY HEMODYNAMIC STENOSIS

a) common femoral artery upstream: PSV = 79 cm./sec.
b) over the stenotic segment: aliasing, PSV = 185 cm./sec. (PSV ratio within the stenosis vs the adjacent upstream segment greater than 2) and reduction in luminal diameter
**Peripheral Arterial Stenosis**

**(US Criteria)**

**Superficial Femoral Artery Stenosis**

1. PSV within stenosis = 2.83 m/s
   VS
   PSV in prox. segment = 0, 90 m/sec.

2. Aliasing and color bruit

3. Monophasic waveform (absence of reversed component) recorded just distal to the stenosis

**Duplex Evidence of Arterial Stenosis: Diagnostic Criteria**

1. PSV (> 125 cm./sec.); PSV within or beyond the stenosis compared with the adjacent upstream segment, greater than 2
2. Reduction in luminal diameter, aliasing and color bruit (evidence of vibration in the tissue surrounding arterial narrowing)
3. Just distal to the stenosis: monophasic flow
peripheral arterial stenosis

US criteria

US IN DEEP FEMORAL ARTERY HEMODYNAMIC STENOSIS

over the stenotic segment:

a) aliasing and reduction in luminal diameter
b) high velocity flow (PSV = 296 cm./sec.)
US IN COMMON FEMORAL ART. AND SUPERFICIAL FEMORAL ART. STENOSIS

A) Proximal arteries

a) common fem. art. stenosis: aliasing and reduction in luminal diameter (PSV = 141 cm./s.)
b) over the stenotic segment: aliasing, reduction in luminal diameter and high velocity flow (PSV = 191 cm./s.)
c) popliteal artery: monophasic flow distal to the stenosis
Peripheral arterial stenosis

**US criteria**

**US in common femoral art. and superficial femoral art. stenosis**

**B) Distal arteries:** monophasic, post stenotic flow

- a) origin of the anterior tibial artery
- b) distal anterior tibial art. and peroneal art. (longitudinal scan) and (c) transverse scan
- d) distal posterior tibial artery
Peripheral arterial stenosis

**US criteria**

**PERIPHERAL ARTERIAL OCCLUSION IS CHARACTERIZED:**

1. no flow and no spectral Doppler waveform within an arterial segment

2. the presence of distal flow does not exclude proximal occlusion because collateral circulation may provide these findings

3. waveforms recorded distal to the occlusion are monophasic, in the absence of reversed component
peripheral arterial stenosis

**US criteria**

**COMMON FEMORAL ARTERY ACUTE THROMBOSIS**

a) high resistance flow upstream in the external iliac artery; b) common femoral artery: hypoechoic thrombus with absence of flow (b-mode/color); c) no flow download (ATP)
Peripheral arterial stenosis

US criteria

Peripheral Arterial Occlusion

The presence of distal flow does not exclude proximal occlusion because collateral circulation may provide these findings.

Grading of lower limb artery stenosis.
Effect of collaterals

Excellent collaterals

Poor collaterals

Absence of collaterals
peripheral arterial stenosis

US criteria

COMMON FEMORAL ARTERY ACUTE THROMBOSIS

a) common femoral artery: absence of flow in the segment occluded (color image) and high resistance flow upstream in the artery proximal to the occlusion (Doppler)

b) popliteal artery: the waveform recorded downstream is monophasic, parvus et tardus (activation of collateral branches)
peripheral arterial stenosis

US criteria

COMMON ILIAC ARTERY CHRONIC OCCLUSION

- iliac artery: absence of flow with no spectral Doppler waveform
- downstream: waveforms recorded distal to the stenosis are monophasic in the absence of reversed component (characteristic poststenotic parvus et tardus waveform)
**peripheral arterial stenosis**

**US criteria**

**SUPERFICIAL FEMORAL ARTERY OCCLUSION**

a) upstream, in the artery proximal to the occlusion: high-resistance waveforms

b) occlusion: absence of flow with no spectral Doppler waveform

c) the popliteal artery (distal to the superficial femoral artery occluded) has a characteristic poststenotic parvus et tardus waveform
peripheral arterial stenosis

US criteria

a) occlusion:
no flow, activation of collaterals branches

b) downstream:
poststenotic waveforms

SUPERFICIAL FEMORAL ARTERY OCCLUSION

a) superficial femoral artery occlusion with activation of collateral branches
b) the popliteal artery (distal to the superficial femoral artery occluded) has a characteristic poststenotic parvus et tardus waveform
peripheral arterial stenosis

**US criteria**

**SUPERFICIAL FEMORAL/POPLITEAL ARTERY OCCLUSION**

a) upstream, in the artery proximal to the occlusion: high-resistance waveform

b) occlusion: absence of flow in superficial femoral/popliteal arteries

c) the tibial arteries (distal to the segments occluded) waveforms recorded distal to the stenosis are monophasic in absence of reversed component
POPLITEAL ARTERY OCCLUSION (THROMBUS)

a) upstream, in the artery proximal to the occlusion: high-resistance waveforms
b) occlusion: hypoechoic thrombus with absence of flow and no color/power image
Peripheral arterial stenosis

US criteria

**POPLITEAL ARTERY OCCLUSION (EMBOLUS)**
- occlusion: absence of flow with the color that “paints” the embolus
Peripheral arterial stenosis

US criteria

DISTAL ARTERIES

- U.S. study of distal arteries can be complex (small and deep vessels, with low velocity)
- In the distal vessels, duplex mapping is better at visualizing anterior and posterior tibial artery segments (80-90%) than peroneal artery segments (75-80%)
Peripheral arterial stenosis

US criteria

Anterior Tibial Artery Origin Not Hemodynamic Stenosis

a) Echocolor of the ATA origin: not hemodynamic plaque
b) Spectral analysis: regular triphasic flow waveform
PERIPHERAL ARTERIAL STENOSIS

US criteria

POSTERIOR TIBIAL ARTERY HEMODYNAMIC STENOSIS

a) PSV of the popliteal artery upstream the stenosis = 39 cm./s.
b) reduction in luminal diameter, aliasing and high velocity directly over the stenotic segment (posterior tibial artery), with PSV = 140 cm./s
c) PSV recorded in the posterior tibial artery just distal to the stenosis = 17 cm/s
peripheral arterial stenosis

US criteria

DISTAL LEG ARTERIES STENOSIS/OCCLUSION

- color Doppler US: anatomical and functional (Doppler) map of distal leg arteries with the levels of stenosis and occlusions
- this study is complex, time consuming and highly operator dependent
peripheral arterial stenosis

US criteria

US IN FEMORO-POPLITEAL BY PASS

a) no stenosis/aneurysm in the segment immediately proximal (upstream) and distal (downstream) to the site of intervention

b) spectral Doppler: good flow (biphasic flow) along the graft and in the peroneal artery (distal to the anastomosis)
peripheral arterial stenosis
US criteria

Diagnosis of arterial disease of the lower extremities with duplex ultrasonography. A meta-analysis

detection of a stenosis ≥ to 50 per cent or occlusion
1. in the aortoiliac tract: sensitivity of 86% and specificity of 97%
2. femoropopliteal tract: a sensitivity of 80 % and a specificity of 96 %
3. in the infragenicular arteries: a sensitivity of 83% and specificity of 84%

ANKLE/BRACHIAL INDEX (OR ABI)

- Peripheral artery disease may be revealed by an abnormal ratio between the blood pressure of the ankle and arm (ankle/brachial index, or ABI).
- Normally, the ankle pressure is at least 90% of the arm pressure.
- In peripheral artery disease, the ankle pressure is lower (in severe narrowing, it may be less than 50% of the arm pressure).
THE ANKLE/BRACHIAL INDEX (ABI)

- is an easy detection method
- is important to assess the severity of the arterial disease
- normally, the ankle pressure is at least 90% of the arm pressure. In peripheral artery disease the ankle pressure is lower (in severe narrowing the ABI may be less than 50% of the arm pressure)
- is less reliable in diabetic patients owing to the calcifications and sequential stenoses
### ankle/brachial index

\[
\text{ABI} = \frac{\text{ANKLE BRACHIAL INDEX}}{\text{OMERAL SYSTOLIC ARTERY PRESSURE}}
\]

- **Ratio between the blood pressure of the ankle and arm**
  - DORSALIS PEDIS OR TIBIAL SYSTOLIC ARTERY PRESSURE
  - OMERAL SYSTOLIC ARTERY PRESSURE

<table>
<thead>
<tr>
<th>ABI</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.91-1.30)</td>
<td>normal</td>
</tr>
<tr>
<td>(\leq 0.90)</td>
<td>mild to moderate PAD</td>
</tr>
<tr>
<td>(&lt; 0.50)</td>
<td>severe arterial occlusive disease</td>
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</tbody>
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**ANKLE BLOOD PRESSURE < 50 MMHG: CRITICAL LEG ISCHAEMIA**
the ABI is important not only to assess the severity of the arterial disease, but also as an easy detection method (can also be carried out by nurses and technicians), and as a pathology marker, mainly for cardiovascular mortality in the elderly.

*BMJ 1996; 313: 1440-1443*

*Diagnosis of vascular diseases ultrasound investigations—Guidelines. Italian society for vascular investigation SIDV-GIUV. International Angiology. October 2012*
Peripheral arteries

PERIPHERAL ARTERIES

1. detection of hemodynamically significant stenoses

2. peripheral artery aneurysms

3. monitoring of sites of previous surgical interventions/percutaneous interventions
Common sites for lower limbs aneurysms

PERIPHERAL ARTERY ANEURYSMS

- real time US imaging are the initial non-invasive diagnostic modalities used to study peripheral artery aneurysms
- in presence of thrombus is seen echogenic material that may occlude the lumen, partially or completely
- color Doppler may demonstrate swirling flow within the aneurysm or no color flow if it is completely occluded
- in presence of thrombosis, US can assess the distal run-off and collaterals
US evaluation of peripheral artery aneurysm should include the:

1. maximum diameter of the artery
2. flow velocities
3. patency of outflow vessels
peripheral artery aneurysms

SUPERFICIAL FEMORAL/POPLITEAL ARTERY ANEURYSM
a) proximal superficial femoral artery: aneurysm and thrombus (echogenic material) partially occluding the cavity
b) distal superficial femoral and popliteal arteries: aneurysm and thrombus (echogenic material) completely occluding the lumen
**US IN SUPERFICIAL FEMORAL ARTERY ANEURYSM**

- superficial femoral artery: aneurysm (11x13 mm.) and thrombus (echogenic material) partially occluding the cavity. Good waveform distal to the stenosis.
**US IN SUPERFICIAL FEMORAL ARTERY ANEURYSM**

- superficial femoral artery longitudinal image: aneurysm and thrombus (echogenic material) partially occluding the cavity.
- color doppler demonstrates the typical turbulent flow in the aneurysm sac ("pseudo yin-yang" sign).
peripheral artery aneurysms

SUPERFICIAL FEMORAL ARTERY ANEURYSM
proximal superficial femoral artery: aneurysm and thrombus (echogenic material) partially occluding the cavity
peripheral artery aneurysms

POPLITEAL ANEURYSMS

- the main risk from a popliteal aneurysm is related to embolisation and occlusion
- popliteal aneurysms can burst but this is a much less common complication than embolisation (the opposite of aortic aneurysms where the main risk is the rupture)

**COMpletely ThROMbosed PoPLITEAL AneurYSM**

a) high-resistance waveform upstream (SFA)
b) completely thrombosed popliteal aneurysm (transverse scan)

**COMpletely ThROMbosed PoPLITEAL AneurYSM**

a) completely thrombosed popliteal aneurysm (longitudinal scan)
peripheral artery aneurysms

**US**

**COMpletely THROMBoSED POplITEAL ANEURYsm**

a) upstream to the occlusion (superficial femoral artery): high-resistance waveforms

b) popliteal aneurysm and thrombus completely occluding the cavity
c) downstream (anterior tibial artery): poststenotic waveforms
COMpletely THROMBoSEd POPLITEAL ANEURYSM
a) upstream to the occlusion: high-resistance waveforms
b) popliteal aneurysm and thrombus completely occluding the lumen immediately downstream the origin of the anterior tibial artery
PARTIALLY THROMBOSED POPLITEAL ARTERY ANEURYSM

a) longitudinal scan: aneurysm and thrombus (echogenic material) partially occluding the lumen

b) spectral Doppler study: normal waveforms upstream (common femoral artery) and downstream (popliteal ant posterior tibial artery)
Peripheral artery aneurysms

Partially Thrombosed Popliteal Artery Aneurysm

a) Longitudinal/transverse color Doppler scan: aneurysm and thrombus (echogenic material) partially occluding the lumen

b) Spectral Doppler study: normal waveform
POPLITEAL ANEURYSMS

- popliteal aneurysms are commonly associated with other peripheral aneurysms such as femoral/iliac and aortic aneurysms
- bilateral popliteal aneurysms occur in about 40-50% of patients and about 40-50% of patients will have an associated aortic aneurysm
PATIENT WITH AORTIC AND BILATERAL POPLITEAL ANEURYSM

- popliteal aneurysms are commonly associated with other peripheral aneurysms such as femoral/iliac and aortic aneurysms
PERIPHERAL ARTERIES

1. detection of hemodynamically significant stenoses
2. peripheral artery aneurysms
3. monitoring of sites of previous surgical interventions/percutaneous interventions
lower-extremity arteries
previous surgical/percutaneous interventions

**US EVALUATION OF SURGICAL INTERVENTIONS**

**bypass grafts:**

- an attempt should be made to sample the full length of any bypass graft
- suspected abnormalities should be imaged with gray scale US
- spectral Doppler waveforms should be documented in the native artery proximal to the graft anastomosis, at the proximal anastomosis, at representative sites along the graft, at the distal anastomosis, and in the native artery distal to the anastomosis

**sites having undergone percutaneous interventions:**

- an attempt should be made to sample the site of selective arterial interventions as well as the segment immediately proximal (upstream) and distal (downstream) to the site of intervention
- spectral Doppler waveforms and velocity measurements should be documented
lower-extremity arteries
previous surgical/percutaneous interventions

US IN FEMORO-POPLITEAL BYPASS
(THROMBOSED POPLITEAL ANEURYSM)

a) proximal and distal (b) anastomosis (longitudinal scan): no pathology; c) spectral Doppler along the graft (longitudinal and transverse scan): no abnormalities of the waveforms
lower-extremity arteries
previous surgical/percutaneous interventions

US IN FEMORO DISTAL BY PASS (PROSTHETIC CONDUIT)
a) no stenosis/aneurysm in the segment immediately proximal (upstream) and distal (downstream) to the site of intervention
b) spectral Doppler: good flow is documented along the graft and in the native artery distal to the anastomosis
lower-extremity arteries
previous surgical/percutaneous interventions

US IN SURVEILLANCE AFTER ENDOVASCULAR REVASCULARIZATION
- iliac artery stenosis: aliasing (a) and high velocity flow (b) over the stenotic segment (rt. common iliac artery: PSV = 260 cm/s.) and monophasic flow in external iliac artery (c)
- control after stenting: regular flow in external iliac artery (d)
lower-extremity arteries
previous surgical/percutaneous interventions

EVALUATION OF PERCUTANEOUS INTERVENTION
- US in previous stent placement in popliteal artery: no stenosis in the segment immediately proximal (a.: upstream) and distal (b.: downstream) to the site of intervention
- spectral Doppler: regular flow is documented
lower-extremity arteries
previous surgical/percutaneous interventions

US GRAFT SORVEILLANCE AFTER FEMORO TIBIAL BYPASS WITH VENOUS CONDUIT

a) by bass stenosis (longitudinal/transverse scan)
b) spectral Doppler: poststenotic parvus et tardus waveform distal the graft
lower-extremity arteries
previous surgical/percutaneous interventions

ANASTOMOTIC ANEURYSM
US surveillance after bypass identifies failing grafts
a) e b) common femoral pseudoaneurysm that develops from a suture line defect
Peripheral arteries

US limitation and pitfalls

**DUPLEX ULTRASOUND LIMITATION AND PITFALLS**

- dense arterial calcification can limit diagnostic accuracy
- the distal superficial femoral artery is deep so, in Hunter’s channel, the study of this artery can be complex
- sensitivity is diminished for detecting stenoses downstream from a proximal stenosis
- the US study of the distal arteries is time consuming, highly operator dependent and handicapped by the presence of edema and ulceration
- pitfalls
DUPLEx ULTRASOUND LIMITATION AND PITFALLS

- dense arterial calcification can limit diagnostic accuracy
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- pitfalls
peripheral arteries

US limitation and pitfalls

COMMON FEMORAL ARTERY longitudinal scans

- dense calcification can obscure flow
- download: triphasic flow waveform (indicative of not hemodynamic stenosis)
peripheral arteries

US limitation and pitfalls

COMMON FEMORAL ARTERY PLAQUE WITH DENSE CALCIFICATION

a) common iliac artery plaque. The excessive shadowing does not allow a proper assessment of plaque. But “aliasing” and high flow velocity (PSV = 273 cm/s.) can diagnose an iliac hemodynamic calcified plaque.

b) monophasic, post stenotic, waveform in external iliac artery
peripheral arteries

*US limitation and pitfalls*

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**ANTERIOR TIBIAL ARTERY**

**longitudinal scans**

- dense calcification can obscure flow
- calcification of the anterior tibial artery walls in diabetic patient
Peripheral arteries
US limitation and pitfalls

**DUPLEX ULTRASOUND LIMITATION AND PITFALLS**

- Dense arterial calcification can limit diagnostic accuracy
- The distal superficial femoral artery is deep so, in Hunter’s channel, the study of this artery can be complex
- Sensitivity is diminished for detecting stenoses downstream from a proximal stenosis
- The US study of the distal arteries is time consuming, highly operator dependent and handicapped by the presence of edema and ulceration
- Pitfalls
distal superficial femoral artery (Hunter’s channel):
linear array transducer (a) vs curved array transducer (b)
best images with convex probe!
peripheral arteries

US limitation and pitfalls

DUPLEx Ultrasound Limitation And Pitfalls

- dense arterial calcification can limit diagnostic accuracy
- the distal superficial femoral artery is deep so, in Hunter’s channel, the study of this artery can be complex
- sensitivity is diminished for detecting stenoses downstream from a proximal stenosis
- the US study of the distal arteries is time consuming, highly operator dependent and handicapped by the presence of edema and ulceration
- pitfalls
SUPERFICIAL FEMORAL AND POPLITEAL PLAQUES

a) superficial femoral artery hemodynamic plaque. Over the stenotic segment: PSV = 276 cm/s., with monophasic, post stenotic, waveform download.

b) popliteal artery calcified plaque. The percentage of stenosis can not be evaluated properly, with the study of the velocity (plaque downstream from a proximal stenosis)
SUP. FEMORAL AND POPLITEAL ART. PLAQUES

a) superficial femoral artery hemodynamic plaque. Over the stenotic segment: PSV = 172 cm/s.

b) popliteal artery calcified plaque (PSV = 45 cm/s.). The percentage of stenosis can not be evaluated properly, with the study of the velocity (plaque downstream from a proximal stenosis)
DUPLEx ULTRAsound LIMITATION AND PITFALLS

- dense arterial calcification can limit diagnostic accuracy
- the distal superficial femoral artery is deep so, in Hunter’s channel, the study of this artery can be complex
- sensitivity is diminished for detecting stenoses downstream from a proximal stenosis
- the US study of the distal arteries is time consuming, highly operator dependent and handicapped by the presence of edema and ulceration
- pitfalls
peripheral arteries

US limitation and pitfalls

DISTAL LEG ARTERIES STENOSIS

- color Doppler US: anatomical and functional (Doppler) map of distal leg arteries with the levels of stenosis
- this study is time consuming and highly operator dependent
DUPLEX ULTRASOUND LIMITATION AND PITFALLS

- Accuracy is diminished in aorta and iliac arterial segments in some individuals (due to obesity or the presence of bowel gas)
- The distal superficial femoral artery is deep so, in Hunter’s channel, the study of this artery can be complex
- Dense arterial calcification can limit diagnostic accuracy
- Sensitivity is diminished for detecting stenoses downstream from a proximal stenosis

- Pitfalls
PITFALLS

Aneurysm of the popliteal vein may mimic the aneurysm of the popliteal artery

POPLITEAL VEIN AND POPLITEAL ARTERY ANEURYSMS

- Saccular aneurysm of the popliteal vein (venous flow) and saccular aneurysm of the popliteal artery (arterial flow)
**Pitfalls**

possible the monophasic waveform without steno/occlusion:

- exercise, fever
- downstream infection
- peripheral inflammation
- polineuropaty (diabetic patients!)

**Monophasic flow, but the PSV and the rise time (time between the beginning of systole and systolic peak) are normal**

**Monophasic flow, distal to occlusion or severe stenosis, presents low PSV and longer rise time (time between the beginning of systole and systolic peak)**
Pitfalls
possible the monophasic waveform without steno/occlusion:
- exercise, fever, peripheral inflammation
- polineuropaty (diabetic patients!), arteriovenous fistula

1. monophasic flow without steno/occlusion:
   the PSV and the rise time (time between the beginning of systole and syst. peak) are normal

2. monophasic flow distal to occlusion or severe stenosis:
   the PSV is low and the rise time is long
Peripheral arteries

US limitation and pitfalls

Pitfalls
possible the monophasic waveform without steno/occlusion:
- polineuropaty, diabetic patients

MONOPHASIC WAVEFORMS IN DIABETIC PATIENT:
- monophasic waveforms in distal arteries (PTA, ATA and dorsalis pedis artery), without hemodynamic stenosis. The PSV and the time rise are normal!
Pitfalls

possible the monophasic waveform without steno/occlusion:

- arteriovenous fistula

MONOPHASIC FLOW IN ARTERIOVENOUS FISTULA OF THE FOOT

- arteriovenous fistula of the foot (a): high diastolic flow in ATA, PTA and dorsalis pedis artery (b). The PSV and the rise time (time between the beginning of systole and syst. peak) are normal
- pulsatile component of the vein (c)
Peripheral arteries

US limitation and pitfalls

Pitfalls

It is possible, despite the presence of plaque hemodynamics, a good recovery of the flow downstream.
peripheral arteries

US limitation and pitfalls

in moderate stenosis: possible biphasic wave or normalisation of the waves after the stenosis

COMMON FEMORAL ARTERY HEMODYNAMIC STENOSIS
a) upstream: high-resistance waveform (PSV = 92 cm./sec.); b) color/power Doppler: hemodynamic stenosis with reduced lumen; c) over the stenotic segment: high velocity flow (PSV = 224 cm./sec.); d) biphasic wave distally (popliteal and ant. tibial arteries)
THE ANKLE/BRACHIAL INDEX (ABI)

- in peripheral artery disease the ankle pressure is lower than the brachial pressure
- the ABI is less reliable in diabetic patients owing to the calcifications and sequential stenoses
Peripheral arteries

US limitation and pitfalls

Pitfalls

in diabetic patients the ABI is less reliable

- in diabetic patients: falsely elevated PA recordings owing to the calcifications and rigid arterial walls (medial sclerosis)

FALSELY ELEVATED DISTAL PA OWING TO THE CALCIFICATIONS AND RIGID ARTERIAL WALLS IN DIABETIC PATIENT

- calcification of the vessel walls. ATA: proximal (a), middle (b) and distal (c) and beaded appearance of color flow.
- brachial pressure = 140 mmHg.; ankle pressure = 240 mmHg; ABI = 2
Mirror image artifact in peripheral arteries

- in some of the cases, depending on the angle of insonation and the surface structure of the plaques, the artifact shows a connection with the vascular lumen (this could be erroneously taken for an ulceration or a branch)

**POSTERIOR TIBIAL ARTERY MIA**

- longitudinal (a) and transverse (b) scans: strongly reflecting plaque, on the vessel wall distant from the transducer, of the post. tibial artery
short videos and playlists on ultrasound examinations of the peripheral arteries are available on my youtube channel: http://www.youtube.com/channel/UCij561sX0bQoEjXlWkUpnKg