ECHOCOLOORDOPPLER LESSONS

SUBCLAVIAN AND VERTEBRAL ARTERY ATHEROSCLEROTIC DISEASE: US PARAMETERS

SUBCLAVIAN AND VERTEBRAL ARTERY STENOSIS

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SCA and VA atherosclerotic disease: ultrasound parameters.

SCA and VA stenosis.

INTRODUCTION

In the hemodynamic stenosis of the subclavian artery (SCA) a significantly elevated velocity is present, with change of the waveform from the normal triphasic to monophasic appearance.

The hemodynamic stenosis of the SCA proximal to the vertebral artery (VA) origin may cause characteristic changes in the ipsilateral VA waveform: a mild to moderate SCA stenosis may cause, in the ipsilateral VA, characteristics waveforms with antegrade or bidirectional flow, while, in case of severe proximal SCA disease, a complete reversal of ipsilateral VA flow appears. In case of occlusion, or high grade pre-vertebral SCA stenosis, a completely retrograde waveform in the VA is present.

The VA stenosis may be distinguished by the detection of focal velocities > 100 cm/s. accompanied by disturbed flow in the more distal segment of the VA.

The absence of color/flow in the VA is suggestive of occlusion: in this case the distal VA recanalization is possible for the activation of collateral circulation. A tardus parvus distal VA waveform is suggestive of significant proximal VA stenosis or occlusion.

In this lesson the ultrasound parameters of the SCA and VA stenosis are presented.
1. more frequently: separate origin of AA, lt. CCA and lt. SCA

2. less frequently: common origin of AA and lt. CCA

3. rarely: the lt. CCA originates from AA

4. rarely: a single brachiocephalic trunk is divided into SCAs and in a bicarotid trunk
Subclavian arteries

- **Right SCA**: SCA branches off the brachiocephalic trunk (BCT) and is shorter 2-3 cm. compared with the Lt. SCA.
- **Left SCA**: SCA arises directly from the aortic arch.
Subclavian normal Doppler parameters

normal waveform has triphasic appearance with high resistance

- longitudinal scan (a) and transverse scan (b): a short systolic time and no diastolic velocity
Vertebral artery and thyrocervical trunk

1. The VA is the first branch of the SCA, except in the rare cases in which it originates directly from the aortic arch. The VA ascends posterior to the ICA in the transverse foramina of the cervical vertebrae.

2. The thyrocervical trunk is a branch of the SCA and it divides soon after its origin into four branches: 1) inferior thyroid artery; 2) suprascapular artery; 3) ascending cervical artery; 4) transverse cervical.
Vertebral artery normal Doppler parameters

a. normal PSV for the VA2 segment is approximately 20–60 cm/s, with low resistance

b. at the origin of the VA the mean velocities are slightly higher
Subclavian artery: supraclavicular transverse scanning

- from the lower part of the neck
- we explore: caudally to locate the VA and SCA (a short segment of the VA and a long segment of the SCA should be noted)
- need to study the wall and spectral analysis
Subclavian artery: longitudinal scan

i. a short segment of SCA
ii. a long segment of the VA and of the internal thoracic artery (inferior site of the SCA)
Vertebral artery

- the VA is divided into four anatomical segments
- the VA can/should be examined throughout the course but, for anatomical characteristics, can not be studied with the same accuracy of the carotid arteries
1. SUBCLAVIAN AND VERTEBRAL ARTERIES (stenosis, occlusion, aneurysm)

   a) subclavian artery
      - not haemodynamic stenosis
      - haemodynamic stenosis and occlusion
      - aneurysm

   b) vertebral artery
      - stenosis, occlusion
      - aneurysm
subclavian artery stenosis

RT. SUBCLAVIAN ARTERY

RT. SUBCLAVIAN ARTERY STENOSIS ORIGIN:
NOT SIGNIFICANT STENOSIS

- transverse scan from the lower part of the neck (calcific plaque at the SCA origin)
- need to study the wall and spectral analysis (short systolic time and the diastolic velocity is absent)
Subclavian artery stenosis: atherosclerosis of the right and left SCA.

- US: not hemodynamic plaques of the SC arteries and plaque at the origin of the lt. thyrocervical trunk (TCT)
1. SUBCLAVIAN AND VERTEBRAL ARTERIES (stenosis, occlusion, aneurysm)
   
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   - aneurysm
**US subclavian artery stenosis**

**SIGNIFICANT LT. SUBCLAVIAN ARTERY STENOSIS**

a) Lt. SCA haemodinamic anechoic plaque: aliasing and elevated velocity (PSV = 215 cm/s). Monophasic waveform

b) rt. SCA: biphasic waveform (PSV = 69 cm/s).
SIGNIFICANT SUBCLAVIAN ARTERY STENOSIS

a) haemodinamic plaque at the SCA origin and not haemodinamic plaque at the CCA origin

b) aliasing and significantly elevated velocity in the proximal subclavian artery (=213 cm/s): change in its waveform from the normal triphasic appearance to monophasic waveform
SIGNIFICANT SUBCLAVIAN ARTERY STENO-OCCCLUSION

A. proximal to the origin of the vertebral artery:
   - in this case the ipsilateral VA flow is pathologic

B. distal to the origin of the vertebral artery:
   - in this case the ipsilateral VA flow is not pathologic
A) SIGNIFICANT SCA STENOSIS PROXIMAL TO THE ORIGIN OF THE VA
(blood is stolen by the VA from the contralateral VA)

a) SCA lt. significant stenosis: a monophasic waveform replaces the usual triphasic Doppler signal; b) inversion of the VA lt. flow; c) the lt. VA flow inversion is also evident by comparing its color (blue) with the color of the ipsilateral CCA (red);
b) rt. brachial artery

c) rt VA2 antegrade flow

B. RT SCA OCCLUSION DISTAL TO THE ORIGIN OF THE VA

a) Rt. SCA occlusion distal to the VA origin; b) post stenotic flow in the brachial artery; c) rt VA2 antegrade flow
1. SUBCLAVIAN AND VERTEBRAL ARTERIES (stenosis, occlusion, aneurysm)

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SUBCLAVIAN ARTERY ECTASIA

a) rt. SCA ectasia (1,54 cm.)
b) spectral analysis: turbulent flow ("pseudo yin-yang" sign)
subclavian artery aneurysm

SUBCLAVIAN ARTERY ANEURYSM

a) spectral analysis (upstream)/power/color Doppler: rt. subclavian aneurysm (diam. = 1.28 cm.); b) typical turbulent flow in the aneurysm sac (“pseudo yin-yang” sign); c) angioTC: rt. subclavian aneurysm (diam. = 1.22 cm.)
1. SUBCLAVIAN AND VERTEBRAL ARTERIES (stenosis, occlusion, aneurysm)

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   - aneurysm

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   - aneurysm
VERTEBRAL ARTERY ATHEROSCLEROTIC STENOSIS

- The origin of the VA is the most common distribution, although stenosis may occur throughout its length.
- The relationship between the severity of a VA stenosis and the peak systolic velocity has not been fully assessed.
- VA stenoses may be detected by:
  - Detection of focal velocities > 100 cm/s. accompanied by disturbed flow.
  - A tardus waveform in the more distal VA is possible.
- Distal VA haemodynamic stenoses may manifest themselves as a high resistance waveform.
vertebral stenosis

VERTEBRAL ARTERY NON SIGNIFICANT STENOSIS

a) B mode: VA segment 0 non haemodinamic plaque
b) SCA and VA1: no color/spectral analysis change compared to normal SCA and VA
VA SEGMENT 2 NOT SIGNIFICANT STENOSIS

a) vertebral artery segment 2 not hemodinamic plaque
b) VA1-VA2 regular flow (PSV = 35-28 cm/s)
VA SEGMENT 0 HEMODINAMIC STENOSIS

a) B mode: VA segment 0 calcific plaque
b) VA0 spectral analysis: PSV = 123 cm/s (significant stenosis)
VA SEGMENT 0 Atherosclerotic Hemodynamic Stenosis

a. Insonation of the VA origin: aliasing and turbulent flow (ostial stenoses)
b. More distal VA (AV2): a tardus waveform is indicative of a significant stenosis upstream
VERTEBRAL ARTERY, SEGMENT 2, SIGNIFICANT STENOSIS

a. aliasing and high velocity flow (PSV = 114 cm.s.) on the VA 2 stenosis
b. upstream (PSV = 66 cm.s.) and downstream (PSV = 48 cm.s.) flow of stenosis
Atherosclerotic stenosis of the distal vertebral artery (VA4)

- Distal VA haemodynamically stenoses may manifest themselves as a high resistance waveform in proximal VA segments
**vertebral stenosis**

a) VA4 stenosis: aliasing and PSV = 218 cm/s

b) VA2 high resistance pattern

**VA SEGMENT 4 STENOSIS**

a) VA4 rt.: aliasing and significantly elevated PSV (= 218 cm/s.) indicative of a significant stenosis *(Cut off stenosis > 50%: PSV > 120 cm./sec. Baumgartner R.W. Stroke 1999)*

b) US: VA2 high resistance pattern indicative of significant distal VA stenosis or occlusion
VA4 DIFFUSE SEVERE STENOSIS

a) low velocity in VA4 diffuse severe stenosis

LT. VA2-3 OCCLUSION AND RT VA4 STENOSIS

a. Lt VA1-VA2 high resistance pattern (with a normal diameter)
b. rt VA2-3 high resistance pattern; c. VA4 stenosis (high velocity flow = 160 cm/s) and aliasing
VA 4 RIGHT SEVERE STENOSIS AND VA LEFT OCCLUSION

- VA right: high resistance Doppler waveform in the intertransverse (a) segment in AV4 severe stenosis: elevated velocity (= 202 cm/s.) and aliasing (b, c)
- VA left: VA 2 occlusion (d) and VA4 inverse flow (red color) from controlateral VA (c)
OCCLUSION OF THE VERTEBRAL ARTERY

- detection of a VA with no flow is suggestive of occlusion
- a VA lumen with no flow and filled with echo-poor thrombus (hypoechoic thrombus) is suggestive of a (recent??) occlusion, while the presence of hyperechoic thrombus is suggestive of an (old??) occlusion
**VA OCCLUSION**

- absence of flow within the vessel
  - a. hypoechoic thrombus: suggestive of a recent obstruction
  - b. echogenic thrombus not distinguishable from the surrounding structures: suggestive of an old obstruction
VA OCCLUSION (ACUTE THROMBOSIS)

a. Lt. VA: absence of flow within the vessel and hypoechoic thrombus (in this case: recent thrombosis)
b. rt. VA: color Doppler and spectral analysis are regular
VERTEBRAL ARTERY 4 SEGMENT OCCLUSION

a. VA2 high resistance pattern (with a normal diameter)
b. TCCD: Lt. VA4 occlusion, rt. VA4/ BA with normal flow
VA1-2-3-4 OCCLUSION:

a) angio CT: rt. VA occlusion
b) US: rt. VA occlusion (VA lumen filled with thrombus). Regular lt. VA4 and BA flow
VA2-VA3-VA4 DISSECTION

a) Lt. VA1-2 high resistance pattern
b) VA2 occlusion; c) Lt. VA4 occlusion, rt. VA4/ BA with normal flow
LT. VA OCCLUSION AND RT VA4 STENOSIS

a. Lt VA2 occlusion

b. rt VA2-3 high resistance pattern and VA4 stenosis (high velocity flow = 163 cm/s) and aliasing
RT VA1-2-3 OCCLUSION (ASYMPTOMATIC PT. 67 Y.: DISSECTION) (1):

a. angioCT: rt. VA occlusion
b. US: rt. VA2 occlusion (color)
RT VA1-2-3 OCCLUSION (ASYMPTOMATIC PT. 67 Y.: DISSECTION) (2):

a. angioCT: VA2 occlusion. Patency of VA4 and PICA; CT: nn.
b. US: VA2 occlusion. Patency of VA4 and PICA.
c. rt. and lt. VA with different colors (red and blu) and directions (rt. antegrade flow; lt. retrograde flow). BA with regular flow
VA ATHEROSCLEROTIC OCCLUSION:
DISTAL RECANALIZATION

- in VA occlusion, the distal VA recanalization is possible for the activation of collateral circulation
- tardus parvus distal VA waveforms are suggestive of significant proximal VA stenosis or occlusion
**VA OCCLUSION**
- distal VA recanalization for the activation of collateral circulation

**VERTEBRAL ARTERY OCCLUSIONS**
possible collateral flows distal to the VA2 occlusion

a) case 1: VA3 antegrade waveform (the collateral circulation is good)
b) case 2: VA3 intermittent waveform (the collateral circulation is poor)
c) case 3: VA3 parvus tardus waveform (the collateral circulation is poor)
VA1-VA2 OCCLUSION: distal VA recanalization for the activation of collateral circulation

a. proximal VA occlusion: no flow in VA1-VA2 and distal VA recanalization (for the activation of collateral circulation)

b. VA2: tardus parvus waveform
**VA1 OCCLUSION:**

**VA2 recanalization for the activation of collateral circulation**

a. angioCT: VA1 occlusion and VA2 recanalization

b. US: VA1 occlusion and VA2 recanalization (color and spectral analysis). The collateral circulation is poor.
Vertebral occlusion

VA1-VA2 occlusion: collateral flows distal to the occlusion
a) rt VA 1-VA2 occlusion (VA lumen filled with thrombus)
b) rt VA2-VA3 download: intermittent waveform
VA1-VA2 OCCLUSION:

**distal VA recanalization for the activation of collateral circulation**

- **a.** proximal VA occlusion: no flow in VA1-VA2
- **b.** VA3-4 recanalization (color and spectral analysis). The collateral circulation is good.
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Vertebral aneurysm

VA2 Aneurysm
- Lt. VA: linear probe. VA2 aneurysm diam. = 6.9 mm.; neck aneurysm = 4.6 mm.
- Flow upstream and in the aneurysm
VA ANEURYSM

- Lt. VA: linear (a) and convex (b) probe. VA2 aneurysm: diam. = 5.7/5.6 mm.
short videos and playlists on echocolor Doppler of the extracranial vessels are available on 
https://www.facebook.com/francoaccorsiecodoppler/ and my youtube channel: 
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