ECHOCOLORDOPPLER LESSONS

CERVICAL ARTERIAL DISSECTIONS:

_VERTEBRAL ARTERY DISSECTIONS_

Franco Accorsi
Cervical arterial dissections: vertebral artery dissections.

INTRODUCTION

The echocolor Doppler is an excellent tool in screening for vertebral dissection defined as the splitting of the arterial wall of the vertebral artery.

In the vertebral artery dissection, ultrasonographic specific signs (segmental dilation of the vessel, eccentric channel) are detectable in only 20% of patients, while nonspecific signs (low reflective thrombus, high-resistance spectral waveform, or absence of flow with no spectral Doppler waveform) are detectable in 92% of patients.

Emergency echocolor Doppler is very useful in the initial assessment of patients who are thought to have a vertebral dissection (unilateral headache without focal neurology): although the echocolor Doppler most frequent signs are indirect and not specific, an abnormal pattern of flow is identified in more than 90% of patients.

In this lesson the echocolor-Doppler findings of the vertebral artery dissections will be presented.
CERVICAL ARTERIAL DISSECTION

- is defined as the splitting of the arterial wall of the carotid or vertebral artery
- is generally characterized by an intramural hematoma, causing some degree of narrowing of the true lumen and an intimal tear

1. spontaneous (no evidence of preceding trauma)
2. traumatic

spontaneous ICA or VA dissections

- about 2% of all ischemic strokes
- 10 to 25 % of ischemic stroke in young and middle-aged patients
CERVICAL ARTERIAL DISSECTION

PATHOGENESIS 1°

between the intima and media

stenosis and thrombosis

HEMATOMA

between the media and adventitia

aneurysmal dilatation

Once a tear occurs in the wall of the artery, blood is allowed to enter between the layers of the wall of the artery (hematoma). The splitting of the layers results in:

- **stenosis** (hematoma is formed between the intima and media)
- **aneurysmal dilatation** (hematoma is located between the media and adventitia)
CERVICAL ARTERIAL DISSECTION

PATHOGENESIS 2º

ANOTHER SUGGESTED MECHANISM:
intramural hemorrhage forms through ruptures of the vasa vasorum without intimal ear, especially if the wall is arteriopathic
SUGGESTED MECHANISM: ATHEROSCLEROSIS?

- Atherosclerosis does not appear to be contributing although embolism is usually considered the main mechanism of ischemic stroke in CAD.

In a study of 130 pts with ICAD investigated with MR and CT, there was:

- No or minimal evidence of ATS in craniocervical arteries and ascending aorta.
- And chronic asymptomatic cerebral infarcts were not observed.

*Benninger DH. Stroke 2004*
EXTRACRANIAL DISSECTION
vertebral artery dissection
VA DISSECTION

The vulnerability of the extracranial portion of the VA to strain and sudden neck movement has been explained:

1. high mobility when passing through the transverse foramina of cervical spines
2. the change of direction from vertical to horizontal at the level of the first cervical vertebra, after which the artery becomes fixed

169 consecutive pts with 195 sVAD

LOCATION OF SVAD:

- pars transversaria V2 (35%
- atlas loop V3 (34%)
- in V1 (20%)
- intracranial V4 (11%)

Marcel Arnold. Vertebral Artery Dissection. Stroke. 2006
**CERVICAL ARTERIAL DISSECTION**

**PAIN**
- the characteristic unilateral headache develops in 2/3 of pts: pain is usually the initial manifestation and the median time to the appearance of other symptoms is four days
- most commonly in the frontotemporal area
- occasionally involves the entire hemicranium or the occipital area

<table>
<thead>
<tr>
<th>CRANIAL NERVES PALSY</th>
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<td>oculosympathetic palsy (consisting of miosis and ptosis)</td>
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<td>the lower cranial nerves are the most commonly affected</td>
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<td>the involvement of various combinations of nerves has been described</td>
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**TYPICAL CLINICAL MANIFESTATIONS**
1. first: local symptoms and signs
2. then: ischaemic event

**ASYMPTOMATIC**

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<th>ISCHEMIC MANIFESTATIONS</th>
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<td>cerebral or retinal ischemic symptoms are reported in 50 to 95 percent of pts</td>
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<td>TIA or transient monocular blindness usually precedes the ischemic stroke</td>
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<td>only about one fifth of pts have an ischemic stroke without any warning signs</td>
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CERVICAL ARTERIAL DISSECTION

MECHANISMS UNDERLYING LOCAL SYMPTOMS AND SIGNS
(consequences of haematoma)

1. local symptoms and signs (headache and neck pain): attributable to a distension of the ICA/VA by the mural haematoma stimulating pain-sensitive receptors (*)

2. cranial-nerve palsies or Horner’s syndrome from stretching of sympathetic-nerve and cranial-nerve fibres by:
   - an enlarged carotid artery (§)
   - more rarely, cervical-root injury (+,°) caused by compression from an enlarged VA

CERVICAL ARTERIAL DISSECTION

RELATIONSHIP BETWEEN CAD AND THROMBOEMBOLIC DISEASE

UNDERLYING MECHANISM OF ISCHEMIC STROKE IN CAD:
1. embolic ?
2. hemodynamic ?

RETROSPECTIVE STUDY
(40 pts suffering from ischemic stroke and ICAD)

- embolic origin (territorial infarcts including cortical and subcortical ones): 92.2% of all infarcts
- hemodynamic origin (any infarct located between 2 arterial territories, referred to as “junctional” and “watershed” infarcts): 7.7%

Lucas C. Stroke 1998
VA DISSECTION AND ISCHEMIC STROKE

- ischemic manifestations are ischemic stroke in 67-85% and TIA in 10-16% with at least one of them occurring in 77-96% of the pts

*Saeed AB. Can J Neurol Sci 2000; Arnold M; Stroke 2006*
VA DISSECTION

US DIAGNOSIS
VA DISSECTION

US TECHNIQUES

1. ACUTE PHASE

2. FOLLOW UP
VA DISSECTION

ACUTE PHASE

IN VA DISSECTION US ARE:

- SENSITIVE
- RARELY SPECIFIC

A) US NONSPECIFIC SIGNS:

(These nonspecific signs are present also in cases of arteriosclerotic VA obstruction. Clinic and the absence of atherosclerotic plaques directs to the diagnosis of dissection.)

- low-reflective thrombus
- high-resistance spectral waveform for further downstream obstacle
- absence of flow with no spectral Doppler waveform

B) US "TYPICAL" SIGNS (LESS FREQUENT):

- intimal flap, double-lumen
- segmental dilatation of the vessel
VA DISSECTION
ACUTE PHASE

PATHOGENESIS

1. VA STENOSIS AND THROMBOSIS
US nonspecific signs (low-reflective thrombus)

- this is nonspecific feature also present in acute thrombosis
- this should indicate the possibility of a dissection in the appropriate clinical setting (young patient with headache)
US nonspecific signs: high-resistance spectral waveform
These nonspecific sign is present also in cases of arteriosclerotic VA obstruction. Clinic and the absence of atherosclerotic plaques directs to the diagnosis of dissection)
**US nonspecific signs: high-resistance spectral waveform**

These nonspecific sign is present also in cases of arteriosclerotic VA obstruction. Clinic and the absence of atherosclerotic plaques directs to the diagnosis of dissection.
US nonspecific signs: high-resistance spectral waveform and low-reflective thrombus

These nonspecific signs are present also in cases of arteriosclerotic VA obstruction. Clinic directs to the diagnosis of dissection
VA DISSECTION

ACUTE PHASE

AV1-2 SPONTANEOUS DISSECTION

US "typical" morphological findings

- intimal flap
- double-lumen

"typical" flow pattern

- alternating flow with high resistance and high-speed (possible segmental stenosis caused by dissection)
VA DISSECTION

ACUTE PHASE

AV2 BILATERAL SPONTANEOUS DISSECTION

AV 2 dx.

AV 2 sx.

AV BILATERAL DISSECTION

- AV sx.: intimal flap (US "typical" sign)
- AV dx.: low-reflective thrombus (US nonspecific sign)
VA DISSECTION

ACUTE PHASE

PATHOGENESIS

2. VA ANEURYSM
VA DISSECTION

ACUTE PHASE

BOTH ICA AND VA SPONTEOUS DISSECTION

US "TYPICAL" MORPHOLOGICAL FINDINGS

- segmental dilatation of VA (and ICA stenosis)

- in a review of 200 pts with spontaneous extracranial artery dissection, the ICA was affected in 76% (unilateral in 62%, and bilateral in 14%), the VA in 18% and both ICA and VA in 6%

In a review of 200 patients with spontaneous extracranial artery dissection, the ICA was affected in 76% (unilateral in 62%, and bilateral in 14%), the VA in 18% and both ICA and VA in 6%. Sandman W. et al. J Vasc Surg 1984
VA DISSECTION

ACUTE PHASE

AV AND ICA SPONTANEOUS DISSECTIONS

A) AV3 lt. aneurysm: this aneurysm is recognized by ultrasound (diameter = 0,57 cm.)
B) ICA rt. (aneurysm) and C) ICA rt: (hematoma/stenosis). This ICA dissections are missed by US because:
1. they do not cause hemodynamic stenosis and
2. are located outside the arterial segments directly visible by US
VA DISSECTION

ACUTE PHASE

TCCD CAN NOT GIVE SPECIFIC IMAGES

TCCD can not give specific images but important information on the potential for development of stroke because can show:
1. reduced blood flow velocity (intracranial stenosis/occlusion)
2. microembolic signals may be the harbingers of a stroke

- the prognosis of stroke is related to the severity of the initial ischemic insult and the extent of collateral circulation
**VA DISSECTION**

**ACUTE PHASE**

**TCCD CAN NOT GIVE SPECIFIC IMAGES**

**VA4 SPONTANEOUS DISSECTION**

**TCCD NONSPECIFIC SIGNS:**

1. high-resistance spectral waveform upstream (V3 segment)
2. V4 segmental stenosis and post stenotic flow downstream

- these are nonspecific features also occurring in high-grade atherosclerotic stenosis: they should indicate the possibility of a dissection in the appropriate clinical setting
- US abnormalities should always be followed up with another imaging modality
CASE REPORT
ACUTE PHASE

AB SPONTENEOUS DISSECTION

AB occlusion

US nonspecific signs in spontaneous AB dissection

- VA 2 bilateral high-resistance spectral waveform upstream and AB occlusion (US nonspecific sign)
CERVICAL ARTERIAL DISSECTION: A DYNAMIC PROCESS

CAD is a dynamic process, and the US/radiographic and clinical findings may change dramatically within days or hours.

- most dissections eventually resolve
- about two thirds of occlusions recanalize
- one third of resulting aneurysms decrease in size

*Schievink WI. N Engl J Med 2001*

US: diagnostic investigation of choice
VA DISSECTION

FOLLOW UP

Dissection is a dynamic process

AV spontaneous dissection:
ECD: acute phase (high-resistance flow) and control 35, 90 days later
VA DISSECTION

FOLLOW UP

Dissection is a dynamic process

FOLLOW UP
control 40 days later: recanalization

ACUTE PHASE
high-resistance flow

AV spontaneous dissection:
ECD: acute phase and control 40 days later
VA DISSECTION
FOLLOW UP

AV spontaneous dissection
acute phase and control 50 days and 14 months later:
decrease in size of the aneurysm

.. one third of aneurysms decrease in size
Schievink WI. N Engl J Med 2001

..MR angiography revealed that dissecting aneurysms of the extracranial ICA
remain stable, decrease in size, or resolve, but they do not increase in size
Hocine Djouhri, AJR 2000
DISSECTION
US: LIMITS
CERVICAL ARTERY DISSECTION

US: LIMITS

- CERVICAL DISSECTION MAY BE MISSED:

1. ECD LIMITS
2. TCCD LIMITS
intramural hematomas may be missed when they are:

1. too small to cause hemodynamic stenosis and

2. located outside the segments well visualized with U.S.
VA DISSECTION
US: LIMITS

this VA dissection may be missed
1. is too small and
2. does not cause hemodynamic stenosis
VA DISSECTION

US: LIMITS

“STUMP FLOW”: DIFFERENTIAL DIAGNOSIS

VA2-3 SPONTANEOUS DISSECTION

US NONSPECIFIC SIGNS: HIGH-RESISTANCE SPECTRAL WAVEFORM AND ABSENCE OF FLOW WITH NO SPECTRAL DOPPLER WAVEFORM

These nonspecific signs are present also in cases of arteriosclerotic VA obstruction.
These signs should indicate the possibility of a dissection in the appropriate clinical setting.
headache may precede ischemic symptoms from the brain or eye by minutes or days

- this localized warning sign should provide an important clue to the d.d. against atherosclerotic disease with neurologic manifestations, which usually precede pain
- this offers a chance to verify the diagnosis and treat the patient before cerebral ischemia develops

CERVICAL ARTERY DISSECTION

TCCD: LIMITS

2. TCCD LIMITS

- test operator and device dependent!
- difficult the study of the distal segments
- difficult (or impossible) to identify a not hemodynamic stenosis
- impossible the study of the intracranial circulation in 20-30% of cases for the presence of hyperostosis
The use of echo contrast agents reduces the rate of ultrasound-refractory patients to 5-10%.

- Postert T. Stroke, 1999
ULTRASOUND DIAGNOSIS OF CAD ACCURACY OF US
In VA dissection the US diagnosis is more difficult than in ICA dissection because the course of VA passing through between transverse process of cervical vertebrae is hard to fully examine.
VERTEBRAL ARTERY DISSECTION

US: ACCURACY 1

- the sensitivity for identifying sVAD is 75-86%
  - all pts with sVAD should undergo cervical MRI and angiography

Benninger DH, Baumgartner RW. Front Neurol Neurosci 2006
VERTEBRAL ARTERY DISSECTION

US: ACCURACY 2

SPONTANEOUS ICA AND VA DISSECTION

- of the sCAD that were diagnosed using MRI, 92% were detected by nUS

the sensitivity of nUS in prospectively detecting sCAD in the ICA and VA is very high

- the already high detection rate of nUS has increased over the last decade, owing to
  - improved technical equipment
  - increased awareness of the disease
  - improvements in the skills of the examiners

*J. Nebelsieck et al. Journal of Clinical Neuroscience 2009*
we did not assess the specificity of nUS for sCAD, but because of the wide spectrum of local symptoms associated with sCAD, including head and neck pain, it is very difficult to assess specificity properly

CONCLUSION 1

US: ACUTE PHASE

1. pain is usually the initial manifestation of CAD (the diagnosis of CAD requires a high level of suspicion!)
2. it is difficult to recommend NR imaging in every patient with unilateral headache without focal neurology, since the yield would be extremely low
3. US techniques are useful in the initial assessment of patients who are thought to have a CAD
4. although the site of dissection is generally not seen, an abnormal pattern of flow is identified in more than 90% of patients
5. a combination of Doppler color-flow imaging and TCCD provides the most useful information in the detection of ICA/VA dissections
6. early US diagnosis allows:
   - to perform early NR tests
   - start with a proper treatment before the neurological symptoms
CONCLUSION 2

US: FOLLOW UP

U.S. follow-up are the test of choice for control of progressive morphological and hemodynamic changes of extra and intracranial vessels (CAD is a dynamic process and the US/radiographic findings may change dramatically within days or hours).
short videos and playlists on echocolor Doppler study of vertebral artery dissections are available on my youtube channel:
http://www.youtube.com/channel/UCij561sX0bQoEjXIWKuPnPnKg