ECHOCOLORDOPPLER LESSONS

CERVICAL ARTERIAL DISSECTIONS:

CAROTID ARTERY DISSECTIONS

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Cervical arterial dissections: carotid artery dissections

INTRODUCTION

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

Carotid artery dissection is associated with hematoma in the wall of the artery. The intramural hematoma can expand towards the intima (resulting in a stenosis of the artery), or the adventitia (resulting in an aneurismal dilatation of the artery).

In the internal carotid artery (ICA) dissection, the main ultrasound findings are:

a) an arterial luminal flap or false lumen (the most specific sign);

b) bulbar and/or proximal ICA hematoma or low-reflective thrombus with or without narrowed true lumen;

b) bulb and origin of ICA with high resistance flow pattern to a stenotic hematoma in the cervical ICA segment not explored directly with the ultrasound ("indirect "sign).

In this lesson the echocolor Doppler findings of the carotid 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:
  1. an intimal tear
  2. an intramural hematoma

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

spontaneous ICA or VA dissections
- about 2% of all ischemic strokes
- about 10/25 % of ischemic stroke in young and middle-aged patients
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 located between the intima/media)
- **aneurysmal dilatation** (hematoma is located between the media/adventitia)
CERVICAL ARTERIAL DISSECTION

PATHOGENESIS 2°

ANOTHER SUGGESTED MECHANISM:
intramural hemorrhage forms through ruptures of the vasa vasorum without intimal ear.
SUGGESTED MECHANISM: Atherosclerosis?

- Atherosclerosis does not appear to be contributing.

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

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

*Benninger DH. Stroke 2004*
CERVICAL ARTERIAL DISSECTION

PAIN
- the characteristic unilateral headache develops in 2/3 of pts: pain is usually the initial manifestation (the median time to the appearance of other symptoms is four days)

CRANIAL NERVES PALSY
- oculosympathetic palsy (consisting of miosis and ptosis)
- the lower cranial nerves are the most commonly affected

TYPICAL CLINICAL MANIFESTATIONS
1. first: local symptoms and signs
2. then: ischaemic event

ISCHEMIC MANIFESTATIONS
- cerebral or retinal ischemic symptoms are reported in 50 to 95 percent of pts
- TIA usually precedes the ischemic stroke
- only about one fifth of pts have an ischemic stroke without any warning signs

ASYMPTOMATIC
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
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:
   - enlarged carotid artery (§)
   - cervical-root injury (+,°) caused by compression from an enlarged VA (rarely)

EXTRACRANIAL DISSECTION

carotid artery dissection
ICA DISSECTION LOCATION

- the commonest location is the cervical segment 2–3 cm. distal to the carotid bulb (area probably subject to most of the stretch during extension or rotation of the neck)

CONSIDERATIONS

1. this segment often is not explored directly with the US
2. differential diagnosis with atherosclerotic stenosis
ICA DISSECTION

US TECHNIQUES

1. ACUTE PHASE

2. FOLLOW UP
ICA DISSECTION

PATHOGENESIS

1. ICA STENOSIS AND THROMBOSIS
ICA DISSECTION

US INVESTIGATIONS

ICA DISSECTION

DIRECT SIGNS OF SCAD

1. ecolucent intramural hematoma
2. “double lumen”
3. stenosis/occlusion of an arterial segment usually not affected by atherosclerosis
   ➢ ICA: distal part of the ICA 2.0 cm. or more downstream of the carotid bifurcation

INDIRECT SIGNS OF SCAD

1. increased or decreased pulsatility upstream or downstream of the suspected arterial lesion
2. > 50% difference in the blood flow velocity compared to the same segment of the artery on the unaffected side
3. detection of intracranial collateral flow

J. Nebelsieck; Journal of Clinical Neuroscience 2009
ICA DISSECTION: US CRITERIA

1. intimal flap with proximal ICA division into two compartments ("direct" sign 1)
2. bulb and/or proximal ICA hematoma or low-reflective occlusive thrombus ("direct" sign 2)
3. bulb and origin of ICA with high resistance flow pattern to a stenotic hematoma in the cervical ICA segment not explored with the U.S. ("indirect" sign)
ICA DISSECTION

ACUTE PHASE

TYPE 1 ("DIRECT" SIGN 1)
intimal flap with proximal ICA division into two compartments

LONGITUDINAL SCANS
ICA DISSECTION

ACUTE PHASE

TYPE 2 ("DIRECT" SIGN 2)

1. bulbar and / or proximal ICA hematoma
2. bulbar and / or proximal ICA low-reflective occlusive thrombus
ICA DISSECTION

ACUTE PHASE

TYPE 3 (INDIRECT SIGNS)

1. absence of atherosclerotic plaques
2. patency of the bulb and the first part of the ICA
3. high resistance flow pattern to the presence of hematoma in the ICA distal segment
ICA DISSECTION

ACUTE PHASE

- in ICA dissections is frequent the combination of the three signs
ICA DISSECTION

ACUTE PHASE

- ICA dissections: combination of the three signs

**TYPE 1-3**

1. intimal flap with proximal ICA division into two compartments ("direct" sign 1)
2. high resistance flow pattern to the presence of hematoma in ICA distal ("indirect" sign 3)

**TYPE 2-3**

1. proximal ICA hematoma ("direct" sign 2)
2. high resistance flow pattern to the presence of hematoma in ICA distal ("indirect" sign 3)
ICA DISSECTION

PATHOGENESIS

2. ICA ANEURYSM
ICA DISSECTION
ACUTE PHASE

ICA SPONTEOUS DISSECTION
aneurysmal dilatation

proximal ICA dissection
ICA DISSECTION
ACUTE PHASE

ICA TRAUMATIC DISSECTION
aneurysmal dilatation and occlusion

aneurysm (proximal ICA segment)
and occlusion (distal ICA cervical segment)
ICA DISSECTION

ACUTE PHASE

ICA SPONTNEOUS DISSECTION
bilateral aneurysmal dilatation

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*
ICA DISSECTION

ACUTE PHASE

TCCD:
- can not provide specific images but
- can provide important information the prognosis of stroke is related to:
  - the extent of intracranial stenosis/occlusion
  - and collateral circulation
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
Patient A: a 40-years-old woman: spontaneous ICA dissection
1. proximal ICA low-reflective occlusive thrombus
2. MCA: occlusion

**TCCD SIGNS OF A POOR PROGNOSIS**
Patient B: a 42-years-old woman: spontaneous ICA dissection

1. **ECD**: proximal ICA low-reflective occlusive thrombus

2. **TCCD**: MCA with good flow for activation of the anterior communicating artery. ACA with reverse flow (positive, red flow): collateral supply via ant. comm. artery

**TCCD SIGNS OF A GOOD PROGNOSIS**
CASE REPORT 2

FOLLOW UP

The same patient B: control after 3 months
- US: ICA, ACA (negative, blue flow) and MCA with normal patterns
- CT: small ischemic infarct

CLINIC: COMPLETE RECOVERY
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CERVICAL ARTERY DISSECTION

FOLLOW UP

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
CERVICAL ARTERY DISSECTECTION

FOLLOW UP

Dissection is a dynamic process

1) Acute phase: “stump flow” and low-reflective occlusive thrombus

2) 33 days later

3) 65 days later: complete recanalization

Recanalization was seen:

- in 82% of the stenoses
- in only 30% of the occlusions

Pelkonen O. Neuroradiology 2003
Dissection is a dynamic process

ICA spontaneous dissection (low-reflective thrombus)
- acute phase and control 20, 40 days later
CERVICAL ARTERY DISSECTED FOLLOW UP

Dissection is a dynamic process

1) acute phase: low-reflective occlusive thrombus

2) 5 days later

3) 25 days later: recanalization

recanalization was seen:

- in 82% of the stenoses
- in only 30% of the occlusions

*Pelkonen O. Neuroradiology 2003*
Dissection is a dynamic process

ICA spontaneous dissection (aneurysm and intimal flap)
- acute phase and control 7 days, 3 and 12 months later

- one third of aneurysms decrease in size

Schievink WI. N Engl J Med 2001
CERVICAL ARTERY DISSECTECTION

FOLLOW UP

Dissection is a dynamic process

1) acute phase: “stump flow” and high velocity flow (stenosis)

2) 12 days later: recanalization
CERVICAL ARTERY DISSECTED

FOLLOW UP

Dissection is a dynamic process

1) acute phase: “stump flow”

2) 45 days later: stenosis with high velocity flow

3) 90 days later: recanalization in hypoplasia
CERVICAL ARTERY DISSESECTION

FOLLOW UP

ICA spontaneous dissection: high resistance flow

control (one day later)
1. ECD: no more high resistance flow
2. TCCD: regularization of PSV (0.85 m/s)

acute phase
CERVICAL ARTERY DISSECTECTION

FOLLOW UP

Dissection is a dynamic process

1) acute phase: “stump flow”

2) 5 days later: complete occlusion
DISSECTION
US: LIMITS
CERVICAL ARTERY DISSECTION

US: LIMITS

- CERVICAL DISSECTION MAY BE MISSED:
  1. ECD LIMITS
  2. TCCD LIMITS
ICA DISSECTION

US: LIMITS

ECD LIMITS

intramural hematomas may be missed when they are:

1. too small to cause hemodynamic stenosis and
2. located outside the arterial segments directly visible by US
this ICA dissection (stenosis) may be missed
1. is too small to cause hemodynamic stenosis and
2. located outside the arterial segments directly visible by US
ICA DISSECTION

US: LIMITS

this ICA dissection (aneurysmal dilatation) may be missed
1. this aneurysm does not cause hemodynamic changes and
2. is located outside the arterial segments directly visible by US
In the case of distal cervical ICA haemodynamic dissection, U.S. can record high resistance flow (non-specific sign) but can not differentiate ICA dissection from other pathology (atherosclerosis/cardioembolism) with obstruction of distal ICA.
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

_Y.-K. Kim, S. Schulman / Thrombosis Research 123 (2009)_
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 if 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
CERVICAL ARTERY DISSECTION

US: ACCURACY 1

SPONTANEOUS ICA DISSECTION CAUSING ISCHEMIA

- in pts with carotid territory ischemia: sensitivity = 96%
  - US allows the reliable exclusion of sICAD

*Benninger DH, Baumgartner RW. Front Neurol Neurosci 2006*
CERVICAL ARTERY DISSECTION
US: ACCURACY 1

SPONTANEOUS ICA DISSECTION
WITH NO CAROTID TERRITORY ISCHEMIA

- in pts with no carotid territory ischemia (but headache, neck pain, Horner syndrome, or palsy of the cranial nerves on the side of dissection): the sensitivity of US for assessing sICAD which causes is about 70%

- all pts with clinical suspicion of sICAD causing no ischemic event should undergo cervical MRI and angiography

Benninger DH, Baumgartner RW. Front Neurol Neurosci
CERVICAL 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

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 carotid artery dissections are available on my youtube channel: http://www.youtube.com/channel/UCij561sX0bQoEjXlWKuPnKg