Dissection of the Cervico-Cerebral Arteries – Ultrasonographic Characteristics

Bajkó Z, Bălașa Rodica, Stan Camelia, Moțățăianu Anca

Department of Neurology, University of Medicine and Pharmacy, Tîrgu Mureș, Romania

Background: Dissection of the cervical and cerebral arteries represents the leading cause of non-atherosclerotic stroke in young adults. The diagnosis can be difficult as the presentation may be variable. The ultrasound (US) examination is the first diagnostic procedure, because is non invasive and informative.
The **aim** of this study was to analyse the ultrasonographical characteristics of the cervico-cerebral artery dissections (CCAD).
Patients and methods: We analyzed 8 consecutive cases of CCAD examined in the Ultrasound Laboratory of Neurology Clinic I from Tîrgu Mureș, Romania over a 3-year period. The mean age of the patients was 39.5±12.1 (min. 24, max. 60), the male/female ratio: 1.
Results: In 5 cases the diagnosis was established based on the ultrasound findings, in 2 cases was confirmed by angiography and in one case by MRI angiography. In 3 cases the CCAD occurred at the level of the proximal internal carotid artery (ICA), in 2 cases at distal ICA, in one case the common carotid artery, in 1-1 cases the proximal and distal part of the vertebral arteries. The most frequent ultrasound finding suggestive for CCAD was the hypoechogenic wall haematoma (3 cases). The hyperechogenic intimal flap occurred in 2 cases, the classical double lumen only in one case. In three cases the ultrasound examination revealed only indirect signs of occlusion. In one case the ultrasound findings were not suggestive for ICA dissection, the diagnosis was confirmed based on the angiography findings.
Conclusions: Color duplex ultrasound examination is an important diagnostic method in the diagnosis of CCAD with good sensitivity and specificity. The most frequent ultrasound finding in CCAD is the hypoechogenic mural haematoma. In patients with suspected CAD and negative US, repeated US examinations and further diagnostic imaging, as angiography, MRI, MRI angiography must be performed.

Keywords: cervical artery dissection, stroke, ultrasound

Introduction

The dissection of the cervical and cerebral arteries (CCAD) is the leading cause of ischemic strokes in young adults [1,2,3].

The annual incidence of spontaneous carotid artery dissection ranges from 2.5 to 3/100000 and of spontaneous vertebral artery dissection from 1 to1.5/100000 [2].

The term "dissection" comes from the Latin verb disseco, meaning the separation of anatomic structures. As it is applied to vascular pathology, it relates to the separation of the different layers that constitute the arterial wall. This can occur spontaneously, or it may follow blunt trauma to the vessel.

The main pathophysiological finding, which is also the cornerstone of the diagnosis is the intramural hematoma, caused by a tear in the intima (the intraluminal blood dissect along the vessel wall layers), the rupture of vasa vasorum (causing direct hemorrhage into the arterial wall) or an underlying arteriopathy impairing vasomotion [4, 5, 6, 7]. The intramural hematoma induces narrowing of the lumen, which may progress to total occlusion. If the blood reenters to the true lumen a false lumen occurs. If the hematoma dissects beneath the adventitia it may lead to the formation of a pseudoaneurysm. The false lumen may remain patent, resolve completely or thrombose, causing lumen narrowing. The thrombosed dissection lumen may become the source of embolisation, which is the main mechanism of TIA or stroke [8, 9, 10]. Carotid and vertebral artery dissections can also induce cerebral ischemia by hemodynamic compromise of the distal vasculature due to luminal narrowing.

Extracranial dissections most commonly involve the media or subadventitial layers of the vessel, whereas intracranial dissections are usually subintimal.

The gold standard for the diagnosis of CCAD was the digital substraction angiography (DSA). DSA was gradually replaced by new imaging techniques as CT (computer tomography) and CT angiography, MRI (magnetic resonancy imaging), MRI of the neck and MR angiography. The latter methods are accurate in detecting an intramural vessel hematoma with high sensitivity. Neurovascular ultrasound (US) plays an important role as a screening method due to non-invasiveness, broad availability and its characteristic or even pathognomonic direct or indirect findings [11].

The aim of this study was to report our experience in the ultrasonographical diagnosis of the cervical and cerebral artery dissections.

Patients and methods

We analyzed 3500 duplex ultrasound records (performed over a 3-year period: 2008–2010) of the patients examined in the Ultrasound Laboratory of Neurology Clinic I, Mureș County Clinical Emergency Hospital.

The examinations were performed with an ACUSON Antares™ ultrasound system (VFX13-5 MHz linear Transducer, PX4-1 MHz transcranial transducer, CW5 Doppler Pencil Transducer).

In all patients the arteries of the neck were investigated by 5MHz extracranial Doppler sonography and color-coded duplex sonography (VFX13-5 MHz linear Transducer).

Table I. Demographical characteristics, ultrasound findings and additional imagistic methods

No.	Sex	Age	The affected vessel	Ultrasound findings	Additional imagistic methods
1.	F	54	proximal vertebral artery	mural hematoma, intimal flap	–
2.	F	60	common carotid artery	double lumen, intimal flap	–
3.	F	37	extracranial internal carotid artery	no ultrasound findings	DSA
4.	F	24	intracranial internal carotid artery	"stump flow"	MRA
5.	M	35	intracranial internal carotid artery	"stump flow"	DSA
6.	M	28	extracranial internal carotid artery	mural hematoma	–
7.	M	40	distal vertebral artery	"stump flow"	–
8.	M	38	extracranial internal carotid artery	mural hematoma	–

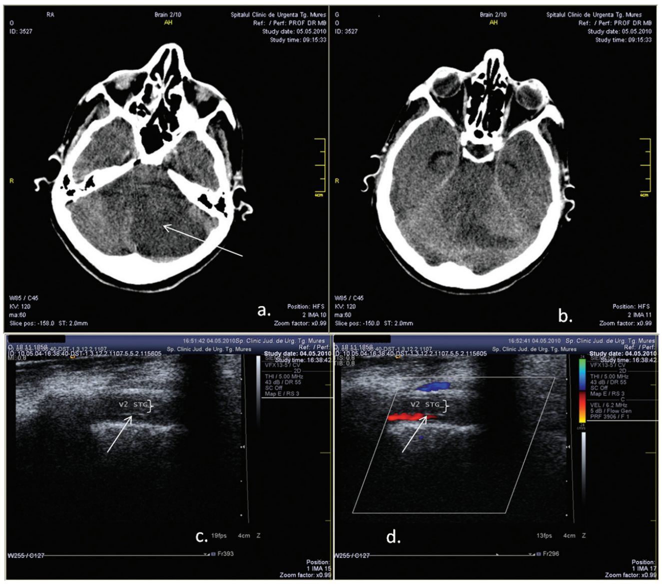

Fig. 1. Patient nr. 1. Vertebral artery dissection. Cranial CT examination- cerebellar and brainstem infarction secondary to vertebral artery dissection (a., b.). Ultrasound examination (c.- B mode, d.- Color mode) of the V1 vertebral artery- characteristic mural hematoma (white braces c., d.) and intimal flap (white arrow c., d.)

The periorbital arteries were examined by CW5 Doppler Pencil Transducer. The CW and color-coded duplex investigation included the examination of the common carotid arteries (CCA), the internal carotid arteries (ICA) and external carotid arteries (ECA) and the vertebral arteries (VA). The intracranial vessels were examined by transcranial color-coded sonography (TCCS, PX4-1 MHz transcranial transducer).

We focused on direct signs of vessel abnormality such as stenosis or occlusion, hypoechogenic vessel wall hematoma, hyperechogenic intimal flap and double lumen. We also followed the indirect signs of dissection induced stenosis or occlusion, such as increased or decreased pulsatility proximal or distal to the lesion, and the collateral or retrograde flow.

The transcranial color coded examination included the documentation of the flow properties of the anterior, middle, posterior cerebral arteries, distal vertebral arteries and basilar artery.

Eight of the 3500 patients with cerebro-vascular disease referred for carotid sonography were found to have CCAD. The mean age of the patients was 39.5±12.1 (min. 24, max. 60), the male/female ratio: 1. The mean age of the female patients was higher (43.7±16.3 vs. 35.2±5.2 years).

Results

The demographical data, the affected vessels, ultrasound findings and the additional diagnostic methods are presented in Table I.

In the majority of the cases the dissection was spontaneous, only in 2 cases we found minor traumatism in the

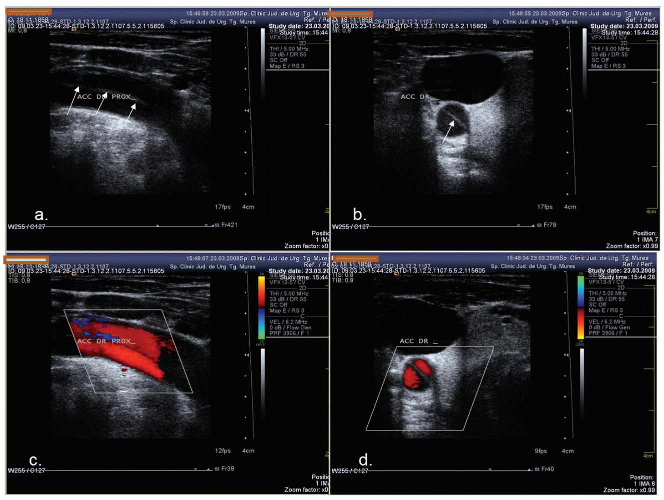

Fig. 2. Patient nr. 2. Common carotid artery dissection-ultrasound examination. The characteristic hyperechogenic intimal flap and double lumen. (a.,b.- B mode ultrasound examination, b., c.- Color mode ultrasound examination).

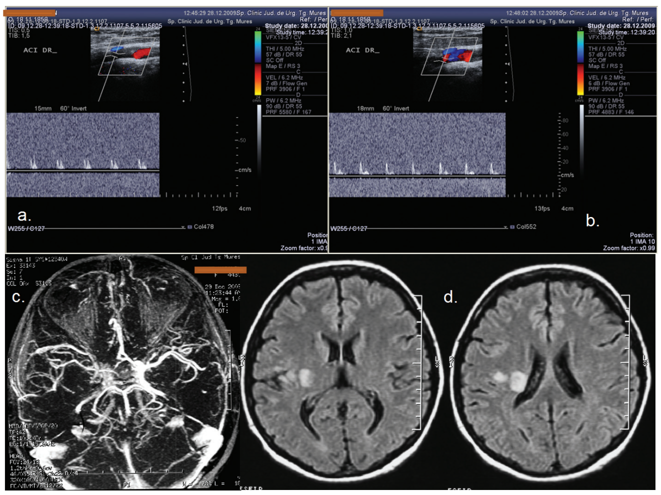

Fig. 3. Patient nr. 4. Ultrasound examination- Duplex mode (a., b.). Indirect signs of distal (intracranial) internal carotid artery occlusion- extracranial ICA is permeable, with "stump flow". MRI angiography (c.)- no flow signal in the intracranial internal carotid artery. Cerebral MRI examination - fluid attenuated inversion recovery sequence (FLAIR) (d.)- cerebral infarction in the right MCA territory.

medical history (case no. 4 – minor traumatism immediately before the onset of the symptoms, case no. 7 – minor traumatism 4 days before the onset of the symptoms).

In 7/8 cases the dissection was symptomatic, in one case (case no. 2) the dissection was diagnosed after a routine ultrasound examination, this patient was treated before (surgically) for aortic dissection.

There was no difference between females and males regarding the frequency of vertebral artery dissection (VA dissection occurs in 25% of the cases). The extracranial part of the carotid arteries was affected more frequently than the intracranial segment.

In 5/8 cases the diagnosis was established based on the ultrasound findings, in 2/8 cases it was confirmed by angiography and in one case by MRI angiography. In 3/8 cases the CCAD occurred at the level of the extracranial (proximal) internal carotid artery (ICA), in 2/8 cases at intracranial (distal) ICA, in one case the common carotid artery, in 1-1 cases the proximal and distal part of the vertebral arteries.

In the intracranial dissection cases the diagnosis was based on characteristic anamnesis (minor trauma and pain – case no. 4, 7), indirect ultrasound signs of vessel occlusion (case no. 4, 5, 7) and additional imagistic methods (case no. 5 – DSA, case no. 4 – MRA). In the majority of the extracranial dissection cases we found characteristic ultrasound signs suggesting dissection and it was not necessary to apply additional imagistic methods.

The most frequent ultrasound finding suggestive for CCAD was the echolucent (hypoechogenic) wall haematoma (mural haematoma) (3 cases) (Figure 1). The hyperechogenic intimal flap occurred in 2 cases (Figure 1, 2), the classical double lumen (false lumen) only in one case (Figure 2). In three cases the ultrasound examination revealed only indirect signs of occlusion (Figure 3).

In one case the ultrasound findings were not suggestive for ICA dissection, the diagnosis was confirmed based on the angiography findings.

Discussion

The dissection of the cervical and cerebral arteries is a relatively rare condition but it is diagnosed with an increasing frequency [12]. It occurs predominantly in the middle adult years.

Arnold et al. [13] in a study of the largest reported series (696 patients) showed that males are more commonly affected (57%). In our study the male/female ratio was 1. The mean age of women was 42.5 years (similar with our results: 43.7±16.3). They found a higher mean age in the male group compared with our results (47.5 years vs. 35.2±5.2). Probably due to the small group of patients we did not found multiple dissections. Arnold et al. [13] reported multiple dissections in 18% of the female and 10% of the male patients.

The diagnosis is currently based on neuro-radiological imaging techniques, such as DSA, CT or MR angiography [11]. The ultrasound examination is very useful to screen young stroke patients or suspected symptoms for dissection, to assess the intracranial vascular hemodynamics and to monitor the recanalization process [11].

Different studies on ultrasound diagnosis have reported a good accuracy in detecting cervical and cerebral artery dissection. According to Nebelsieck et al. the sensitivity of ultrasound examination in detecting spontaneous cervical artery dissection is high, about 92% for both vascular territories (carotid and vertebral arteries) [14].

Treiman et al., Sturzenegger et al. and Baumgartner et al. have reported sensitivities ranging from 80 to 95% [11,15,16,17].

In our study in the majority of cases (7/8) the ultrasound findings were very sugesstive for dissection, only in one case the US examination was negative. In 5/8 cases the diagnosis was possible based on the anamnesis, clinical data and ultrasound.

US examination provides direct visualization of the pathological findings related to dissection and hemodynamic information: flow velocities, flow direction within the true and false lumen and evaluates vessel and lumen patency. It is able to demonstrate a false lumen even if the lumen is thrombosed.

The most important direct ultrasound signs are the mural hematoma (causing tapering luminal stenosis), double lumen and intimal flap. The most frequent finding is the mural hematoma (thickened and hypoechogenic vessel wall). An intimal flap and a perfused false lumen are rare findings [18]. The dissection hematoma typically begins a few centimeters after the origin of the ICA or may be located a few centimeters below the skull base.

In case of distal dissection only the hemodynamic abnormalities can be revealed by ultrasound (stenosis or occlusion), while wall abnormalities are hardly depicted. Specific signs of dissection are hardly detected in the depth of the neck and most dissecting aneurysms are missed [19].

An aortic dissection extending in the carotid arteries is tipically associated with an intimal flap separating the false from the true vessel lumen [18] (case no. 2, Figure 2).

Logason et al. [12] observed four different flow patterns as indirect signs of dissection: absence of flow, staccato flow (monophasic noncontinuous flow, "stump flow"), diminished flow and stenotic flow. They observed the absence of flow in the ICA in 15% of the patients, staccato flow in 50% and diminished ICA flow in 25%.

In our cohort the most frequent hemodinamical abnormality was the "stump flow" (3/8 cases).

The dissection is a dynamic disease process and serial ultrasound examination demonstrates a changing morphological and hemodinamical pattern, often returning to a normal condition over time.

The diagnostic sensitivity of ultrasound is lower in CCAD with low grade stenosis or in patients with local symptoms only (dissecting aneurysm) as compared with those with severe obstruction and ischaemic stroke [11].

Transfemoral DSA is the gold standard for the diagnosis, but it is an expensive and invasive procedure with potential risks and complications. The classic angiographic findings of CAD include the tapering narrowing of the ICA ("string sign" or "rat's tail"), dissection "flaps", tapering occlusion (flame-shaped occlusion) and aneurysmal dilatation of an arterial segment. The most common finding is an irregular stenosis starting about 2–3 cm distal to the carotid bulb and extending along the artery [8].

In our cohort in 2/8 cases it was necessary to confirm the diagnosis by DSA. In the case of patient no. 3 there was a clinical suspicion of dissection, but the ultrasound result was negative. The DSA finding was the dissecting "flap". In the case of patient no. 5 there was a clinical suspicion of dissection and the ultrasound examination revealed indirect signs. The DSA finding was the "string sign".

CT and CT angiography provide non-invasive means of diagnosing CCAD, although they are used much less frequently than MR imaging. Multisection CT angiography provides high resolution and high contrast images of the arterial lumen and vessel wall, and is non-invasive [8].

MRI and MRA (Magnetic Resonancy Angiography) play an increasingly important role in the diagnosis of CAD and can provide a definitive diagnosis. MR imaging findings are typically a periarterial rim of intramural hematoma, which initially becomes hyperintense on T1-weighted images and later on T2-weighted images, surrounding either a normal or narrowed flow void [20].

The MRI and MRA have the following advantages: axial T1-weighted images can detect small hematomas that can be missed with DSA, MRA is an excellent non-invasive way to follow the resolution of dissection over time [2,21], high-resolution 3-T MRI is showing promise in its ability to detect, intracranial dissections and in distinguishing intramural hematoma from thrombus [22]. Contrast-enhanced MRA improves the resolution [23]. This methods are more expensive then ultrasound.

In our study only in 1 case (patient no. 4) the diagnosis was confirmed with MRA (there was a clinical suspicion of dissection and US examination revealed indirect signs of distal ICA occlusion).

In brain MRI the most frequent imaging pattern is acute multiple brain infarcts in a single arterial distribution [24] (Figure 3d). Infarcts typically occur in a borderzone distribution, suggesting a combination of thromboembolic and low-flow hemodynamic mechanisms [25,26,27].

Conclusions

Dissection of the cervical and cerebral arteries is an important cause of stroke in young and middle-aged patients. Accurate and prompt diagnosis is crucial because timely and appropriate therapy can reduce the risk of long-term sequelae.

Color duplex ultrasound examination is a useful technique for diagnosis of this condition with relatively good sensitivity and specificity. The most frequent ultrasound finding in CCAD is the hypoechogenic mural haematoma.

Knowledge of chronologic changes of cervical and cerebral artery dissection and potential pitfalls related to the interpretation of the imagistic findings are important factors for achieving an accurate diagnosis.

In patients with suspected CAD and negative or suggestive but non-specific ultrasound findings repeated US examinations and further diagnostic imaging, as angiography, MRI, MRI angiography must be performed.

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