Ultrasonography of the Temporal, Periorbital and Carotid Arteries in the Diagnosis of Giant Cell Arteritis and its Neuroophthalmological Complications

Results of a Case Control Study in 110 Patients

K. Pfadenhauer
H. Weber

Sonographie der Aa. temporalis, periorbitales und carotis bei der Diagnostik der Riesenzellarteriitis und ihrer neuroophthalmologischen Komplikationen – Ergebnisse einer Fallkontrollstudie bei 110 Patienten

Zusammenfassung

Zielsetzung: Untersuchung des diagnostischen Beitrages der farbkodierten Duplexsonographie der A. temporalis superficialis (STA) und der Karotiden sowie der Dopplersonographie der periorbitalen Arterien bei Patienten mit Riesenzellarteriitis mit und ohne neuroophthalmologische Komplikationen und Patienten mit neuroophthalmologischen Komplikationen bei anderen Erkrankungen. **Methodik:** Die Ultraschallbefunde von Patienten mit neuroophthalmologischen Komplikationen (davon 25 mit Riesenzellarteriitis und 23 mit anderen Diagnosen) wurden mit den Befunden von 62 Patienten mit Riesenzellarteriitis verglichen. Konzentrische hypoechogene Wandverdickungen (sog. Halos) an der STA und den Karotiden wurden als Riesenzellarteriitis-typischer Befund gewertet. Gleiches galt auch für ein nach Kompression fehlendes oder retrogrades Strömungssignal in den periorbitalen Arterien, das nicht mit einer hochgradigen Obstruktion der Karotiden korrespondierte. **Ergebnisse:** Abnorme Befunde an den periorbitalen Arterien und Halos in Kombination mit Stenosierungen an der STA fanden sich häufiger bei Patienten mit Riesenzellarteriitis und neuroophthalmologischen Komplikationen. Dies spricht für eine stärkere Störung der Hämodynamik bei diesen Patienten. Patienten mit Riesenzellarteriitis mit und ohne neuroophthalmologischen Komplikationen hatten ähnlich hohe Raten von Anomalien an der STA (72 vs. 71 %), wohingegen Anomalien der periorbitalen Arterien bei den Patienten mit Riesenzellarteriitis und neuroophthalmologischen Komplikationen klar überwogen (40 vs. 8 %). Nur 1 Patient mit Riesenzellarteriitis ohne neuroophthalmologischen Komplikationen hatte Riesenzellarteriitis-typische Anomalien an den Karotiden. Falsch positive duplexsonographische Befunde an der STA fanden sich bei 9 % der

Abstract

Aim: Evaluation of the diagnostic contribution of colour duplex sonography of the superficial temporal and the carotid arteries and Doppler sonography of the periorbital arteries by analysing the results in patients with giant cell arteritis with and without neuroophthalmological complications and patients with other diagnoses and neuroophthalmological complications. **Methods:** In a case control study, ultrasonographic findings in patients with neuroophthalmological complications (25 giant cell arteritis, 23 non giant cell arteritis) were compared to those of 62 patients suffering from giant cell arteritis without neuroophthalmological complications. Concentric hypoechogenic mural thickening (a so-called halo) was considered as an ultrasonographic finding typical of giant cell arteritis. Absent or retrograde signals not corresponding to carotid occlusive disease were classified as Doppler sonographic findings typical of giant cell arteritis of the periorbital arteries. **Results:** There are higher rates of abnormalities in Doppler sonography of the periorbital arteries as well as halos in combination with stenosis of the temporal arteries in patients with giant cell arteritis with neuroophthalmological complications. This suggests that in patients with giant cell arteritis and neuroophthalmological complications, the haemodynamic situation is more severely disturbed. Patients suffering from giant cell arteritis with and without neuroophthalmological complications had the same rate of temporal artery abnormalities on colour duplex sonography (72 vs. 71 %), whereas abnormalities in the periorbital arteries were clearly different (40 vs. 8 %). Only 1 patient with giant cell arteritis without neuroophthalmological complication had anomalies of the carotid arteries typical of giant cell arteritis. In patients with other diagnoses and neuroophthalmological complications,

affiliation
Department of Neurology, Klinikum Augsburg, Augsburg, Germany

correspondence
Dr. K. Pfadenhauer · Neurologische Klinik, Klinikum Augsburg · Stenglinstr. 2 · 86156 Augsburg ·
Tel.: ++ 49/8 21/4 00 29 91 · Fax: ++ 49/8 21/4 00 29 61 ·
E-mail: karl.pfadenhauer@neurologie.augsburg-med.de

received: 20.7.2004 · **accepted:** 14.12.2005

bibliography
Ultraschall in Med 2006; 27: 329 – 335 © Georg Thieme Verlag KG Stuttgart · New York
DOI 10.1055/s-2006-926555 · Published online February 24, 2006
ISSN 0172-4614

Patienten mit neuroophthalmologischen Komplikationen aufgrund anderer Erkrankungen, nicht aber bei der Dopplersonographie der periorbitalen Arterien. **Schlussfolgerung:** Die farbkodierte Duplexsonographie der STA und der Karotiden und die Dopplersonographie der periorbitalen Arterien sind komplementäre Methoden, die sich für die Diagnostik der Riesenzellarteriitis eignen.

Schlüsselwörter
Sonographie · Riesenzellarteriitis · neuroophthalmologische Komplikationen

the rate of anomalies in temporal artery colour duplex sonography and Doppler sonography of the periorbital arteries was 9% and 0%. **Conclusion:** Colour duplex sonography of the superficial temporal and carotid arteries and Doppler sonograpy of the periorbital arteries are complementary methods and should be part of the evaluation of all patients suspected to suffer from giant cell arteritis.

Key words
Ultrasonography · giant cell arteritis · neuroophthalmological complications

Introduction

Temporal arteritis or giant cell arteritis (GCA) is a systemic vasculitis with a particular affinity to the superficial temporal artery (STA) and the extraocular parts of the central retinal, posterior ciliary and ophthalmic arteries. Less common is the involvement of other branches of the external carotid artery like the occipital arteries, the axillary artery, the internal carotid (ICA), the vertebral and coronary arteries and the aorta [1]. Rapidly progressing visual disturbances and even bilateral blindness are serious complications of the disease [2]. The most common clinical manifestation leading to profound visual loss is arteritic ischaemic optic neuropathy (AION). Less commonly, occlusion of the central retinal artery or its branches, amaurosis fugax, posterior ischaemic optic neuropathy, central homonymous hemianopia and lesions of the oculomotor and abducens nerve have been reported. The pathogenesis of these ischaemic clinical syndromes is believed to be secondary to vasculitis-induced blood flow alterations to the eye, the optic nerve, the retina and the central visual pathways [3]. Up to now, histological diagnosis from a biopsy of the temporal artery is the diagnostic gold standard [4]. Doppler sonography [5–13] and colour duplex sonography (CDS) [14–24] have been used for the direct demonstration of arteritis of the ophthalmic and periorbital arteries (PA), the superficial temporal (STA) and the carotid and vertebral arteries, but also to exclude collateral flow via the superficial temporal artery in severe stenosis of the internal carotid artery (ICA) before biopsy.

CDS of the STA could not only demonstrate stenosis and occlusion of the artery but also perivascular hypoechogenic areas, so-called halos, which were considered to represent inflammatory oedema of the arterial wall. There are discrepancies concerning sensitivity and specificity, however [14–25]. The rate of stenosis and occlusion in GCA patients varied considerably: in some studies, the sensitivity of CDS was increased by the detection of stenoses and occlusions [15, 16] whereas in other studies, it remained unchanged [17]. In one study, the diagnosis of stenosis and occlusion reduced specificity [15]. Absent flow and other abnormalities in Doppler sonography of the periorbital arteries (DSPA) as an indicator of arteritic thrombosis have been considered to be helpful in determining the risk of blindness [6, 7, 10, 12].

In this case control study, we evaluated the diagnostic contribution of CDS of the carotid and temporal arteries and Doppler sonography of the periorbital arteries in GCA patients with and without neuroophthalmological complications (NOC) and in patients with other diagnoses and NOC who were initially suspected to suffer from giant cell arteritis.

Patients with giant cell arteritis

Over a time period of 72 months, 87 patients (60 of them female, median age 74, range 52–90 years) were diagnosed with GCA (n = 87) while being treated in the Departments of Rheumatology, Ophthalmology and Neurology. The diagnosis of GCA was made according to generally accepted criteria [4]. 13 of the 87 GCA patients were diagnosed without biopsy, because of anticoagulation (n = 3), severe ICA stenosis and collateral flow (n = 4) and other reasons (n = 6). In 56 of the 74 patients, biopsies demonstrated GCA (76% of the biopsy group, 64% of all GCA patients).

All patients were studied in the active phase of the disease. 79 GCA patients had received steroids before ultrasonographic examination (median 2 days both for patients with and without NOC, range 1–24 days). Clinical manifestations included typical cranial giant cell arteritis in 76 patients. Large vessels were involved in 7 cases: the involvement of the subclavian and axillary artery in 4 cases was diagnosed by typical angiographic findings and the effect of adequate steroid treatment. In 2 cases, the involvement of the aorta was demonstrated by biopsy of the aortic wall in 1 case, and by typical CT angiographic abnormalities of the aorta and a positive biopsy of the temporal artery in the other case. In another case with vertebrobasilar symptoms, hypoechogenic concentric wall thickening and stenosis of both proximal vertebral arteries and positive biopsy of the temporal artery were found. Occult or silent GCA (i. e. constitutional symptoms without localising vasculitic signs and symptoms) was diagnosed in 4 patients who had positive biopsies and typical halos of the temporal arteries.

In 25 patients (29%), neuroophthalmological complications were found and confirmed by an experienced ophthalmologist (listed in Table **1**). Parts of the data have been published previously [23].

Patients with other diagnosis and neuroophthalmological complications

23 patients (female 16, median age 77 years, range 53–89 years), all initially considered to have TA, were diagnosed with other illnesses: arteriosclerotic vascular disease, 22 cases, Waldenström's disease, 1 case. Unilateral biopsy from the STA was taken in 10 pa-

Table **1** Summary of the Doppler sonography findings of the periorbital arteries and the results of colour duplex sonography of the temporal and carotid arteries in 25 patients with giant cell arteritis and neuroophthalmologicalcomplications[1]

patient/age	*neuroophthalmological complication*	*Doppler sonography periorbital arteries r/l*	*colour duplex sonography temporal artery*	*colour duplex sonography carotid arteries*	*histological finding*
1./82	CRAO r	Abn./GCA	Halo r/l	Plaque r/l	GCA
2./90	AION l	Abn./GCA	Halo r/l	Plaque r/l	GCA
3./68	AION r	N	N	Plaque r/l	GCA
4./73	AION r/l	N	Halo r/l	Plaque r/l	GCA
5./78	AION r	Abn./GCA	Halo/ste r/l	Plaque r/l	GCA
6./74	AION l	N	Halo r/l	Plaque r/l	GCA
7./80	AION l	Abn./GCA	N	Plaque r/l	GCA
8./76	AION r	Abn./GCA	N	Plaque r/l	AS
9./78	AION r	Abn./ICA occlusion	Halo r/l	Plaque l, ICA ste 80% r	GCA
10./78	AION r	N	Halo/ste r/l	Plaque r	GCA
11./76	AF	Abn./GCA	Halo r/l	N	GCA
12./75	N. III r	Abn./GCA	Halo/ste r	Plaque r/l	GCA
13./61	AION r	N	N	N	ND
14./69	CRAO r/l	Abn./ICA occlusion	N	Occlusion ICA r, ICA ste 70%l	ND
15./85	AION r/l	N	Halo r/l	Plaques r/l	IF
16./77	AION	Abn./GCA	Halo r/l	Plaques r/l	GCA
17./78	AION l	N	Halo/ste r/l	ICA ste 80% r ECA ste 50%l	GCA
18./80	AION l	Abn./GCA	Halo r	Plaques r/l	GCA
19./77	AION r	N	Halo l	Plaques r/l	GCA
20./89	AION r/l	N	Halo r/l	ICA ste 50% r/l	GCA
21./82	AF r/l	Abn./GCA	Halo/ste r/l	Plaques l, ICA ste 60% r	GCA
22./81	AF r	N	Halo/ste r/l	Plaques r/l	GCA
23./72	CRAO r/l	Abn./GCA	Halo/ste r, halo l	Plaques r/l	GCA
24./82	PION l	N	Halo/ste r/l	Plaques r/l	IF
25./69	AF r	N	N	Plaques r/l	FB

[1] Abbreviations: Neuroophthalmological complications: AION: Anterior ischaemic optic neuropathy, PION: Posterior ischaemic optic neuropathy, CRAO: Central retinal artery occlusion, AF: Amaurosis fugax, N.III: oculomotor nerve, DSPA: Normal anterograde flow (N); Abnormal flow corresponding to giant cell arteritis (Abn./GCA); Abnormal flow corresponding to ipsilateral giant cell arteritis occluding the ICA (Abn./ICA occlusion); CDS: ste=stenosis, ICA=internal carotid artery, ECA=external carotid artery;Histological findings: GCA: giant cell arteritis, AS: arteriosclerosis, IF: fibrosis of the intimal layer, ND: not done, N: normal, FB failed biopsy.

tients. Biopsies were normal in 3 patients, arteriosclerosis was found in 2, intimal fibrosis in 5 patients. The spectrum of neuroophthalmological complications included anterior ischaemic optic neuropathy (n = 12), central retinal artery occlusion (n = 8), oculomotor nerve lesion (n = 1), thrombosis of the orbital vein (n = 1) and homonymous hemianopia (n = 1).

Methods

Colour duplex sonography (CDS) of the temporal artery

All examinations before the biopsy procedure were performed by one investigator (KP), using a Siemens Sonoline Elegra ultrasound system. A linear array 7.5 MHz transducer (6 – 9 MHz) was used. Standard parameters for the B-mode were: Emission-frequency 9 MHz, dynamic range 50 dB, gain 70 dB. Axial resolution was 0.45 and lateral resolution 0.48 mm. Colour Doppler emission frequency was 5.1 MHz. For the Doppler sonography, a wall filter of 50 Hz and a pulse repetition frequency of 3125 Hz were used.

The common superficial temporal artery and the frontal and parietal branches were examined as extensively as possible in transverse and longitudinal sections. Absent flow in the STA was considered to be an occlusion of the artery, segmental increase of blood flow velocity with wave forms demonstrating turbulence were classified as stenosis. Periarterial hypoechogenic areas (Fig. **1**) were classified as “halo” according to the suggestions by Schmidt et al. [14].

Colour duplex sonography (CDS) of the carotid artery

Examination of the carotid arteries was performed in transverse and longitudinal sections using a Siemens Sonoline Elegra ultrasound system and a 7.5 MHz linear array high resolution transducer (6 – 9 MHz). Standard parameters for the B-mode were: emission-frequency 7.2 MHz, dynamic range 50 dB, gain 34 dB. Colour Doppler emission frequency was 5.1 MHz. For the Doppler sonography, a wall filter of 50 Hz and a pulse repetition frequency of 868 Hz were used. For the classification of the degree of stenosis of the ICA we used the Doppler sonographic and morphologic criteria proposed by Widder et al. [26]. The results were categorised into: normal (N), plaque and stenosis < 50% (P) and stenosis ≥ 50% (St).

Doppler sonography of the periorbital arteries (DSPA)

Doppler frequency shifts were recorded from the periorbital arteries (PA) using a directional continuous wave Doppler device and an 8 MHz ultrasound probe. Compression manoeuvres of the temporal and facial artery were carried out to detect reversed flow

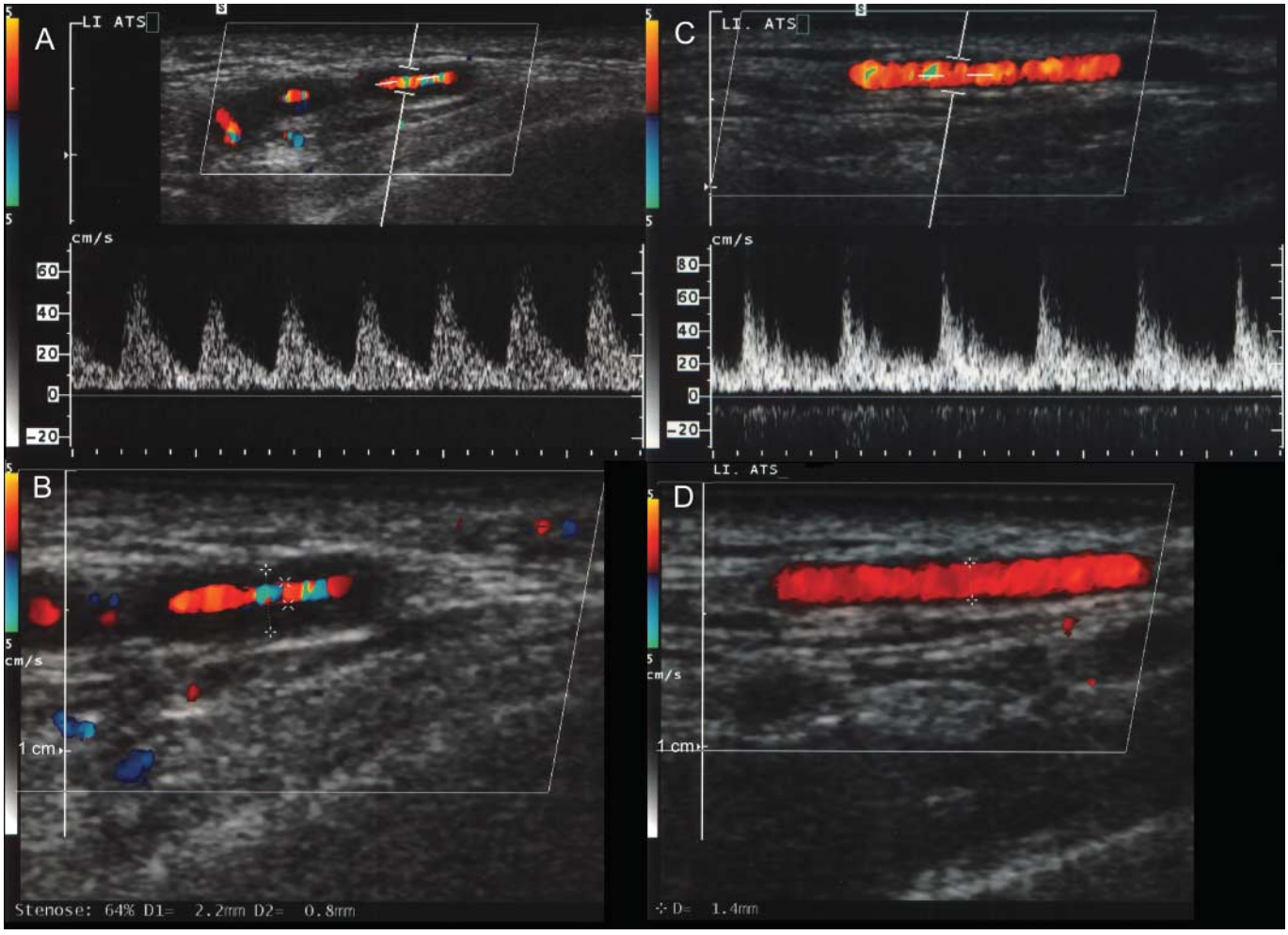

Fig. **1** Colour duplex sonography (CDS) of the superficial temporal artery in a 73-year- old patient (patient 4 from Table **2**) suffering from giant cell arteritis (**A**, **B**), and in a 75-year-old healthy woman (**C**, **D**). CDS longitudinal sections from the anterior branch of the temporal artery show normal perivascular tissue (**D**) and hypoechogenic perivascular tissue corresponding to active giant cell arteritis (**B**). Corresponding pulsed-wave-Doppler spectra from the temporal artery (**A**, **C**), showing normal results.

Abb. **1** Farbdoppler-Sonographie (CDS) der A. temporalis superficialis bei einem 73-jährigen Patienten (Patient 4 aus Tab. **2**) mit Riesenzellarteriitis (**A**, **B**), sowie von einer 75-jährigen gesunden Frau (**C**, **D**). CDS-Längsschnitte des vorderen Astes der A. temporalis zeigen normales perivaskuläres Gewebe (**D**) und echoarmes perivaskuläres Gewebe als Zeichen einer aktiven Riesenzellarteriitis (**B**). Die zugehörigen Puls-Doppler-Spektren der A. temporalis (**A**, **C**) sind normal.

in the PA. According to accepted criteria [26], the results were categorised into: anterograde flow (A), anterograde reduced flow below half of the signal amplitude of the contralateral side (B), absent flow only before compression manoeuvres (C), absent flow (incompressible flow) before and after compression manoeuvres (Ci), reversed flow (D). Abnormal flow patterns B, C and D were considered as manoeuvres (Ci), reversed flow (D). Abnormal flow patterns B, C and D were considered as stenosis related if a > 70% ipsilateral ICA stenosis was present (abn./ICA occlusion). Flow patterns Ci, C and D without associated > 70% ipsilateral ICA stenosis were considered as abnormalities typical of GCA (abn./GCA).

Results

Patients with giant cell arteritis

Colour duplex sonography of the temporal arteries in all 87 GCA patients was abnormal with halos and halos and stenoses in 72% of patients with and 71% without NOC (Table **2**). The rate of halo and stenosis, however, was 32% in NOC-positive and 16% in NOC-negative patients. In the 56 cases confirmed by biopsy, halos were found in 53%, halo and stenosis in 37% of cases with NOC. In the NOC-negative cases, the rates were 54% and 16%, respectively. Carotid arteries in the 87 GCA patients were abnormal in 23 (92%) of the patients with and in 49 (79%) without NOC. From the 56 cases confirmed through biopsy, 95% of the NOC-positive and 76% of NOC-negative patients had abnormalities of the carotid arteries. All anomalies were considered to represent arteriosclerotic vascular disease except in 1 patient without NOC. In this biopsy-negative patient with arm claudication and arteritic stenosis of the axillary artery, a concentric hypoechogenic mural thickening of the common carotid artery was found (Fig. **2**). Stenoses exceeding 50% were found in 14 patients (16%) including 8 with stenosis of the ICA, 3 of them involving the ICA and ECA, 4 ECA and 2 CCA. They were equally distributed in the group with and without NOC.

DSPA in all 87 GCA cases showed a significantly higher rate of abnormal findings (40 vs. 8%) not corresponding to severe carotid artery stenosis in the NOC-positive patients. In the cases confirmed

Table **2** Summary of the Doppler sonography findings of the periorbital arteries and the results of colour duplex sonography of the superficial temporal artery and the carotid arteries in 87 patients with the diagnosis giant cell arteritis and 23 patients with other diagnoses and neuroophthalmological complications (NOC)

diagnosis	*n = patients*	*doppler sonography of the periorbital arteries n = patients*	*colour duplex sonography of the temporal arteries n = patients*	*colour duplex sonography of the carotid arteries n = patients*
giant cell arteritis with NOC	25	normal = 12 Abn./ICA occlusion = 3 Abn./GCA = 10	normal = 7 Halo = 10 Halo/Stenosis = 8	normal = 2 Plaques = 19 > 50 % Stenosis = 4
giant cell arteritis without NOC	62	normal = 54 Abn./ICA occlusion = 3 Abn./GCA = 5	normal = 18 Halo = 34 Halo/Stenosis = 10	normal = 13 Plaques = 38 Halo = 1 > 50 % Stenosis = 10
other diagnoses with NOC	23	normal = 23	normal = 21 Halo = 2	normal = 4 Plaques = 12 > 50 % Stenosis = 7

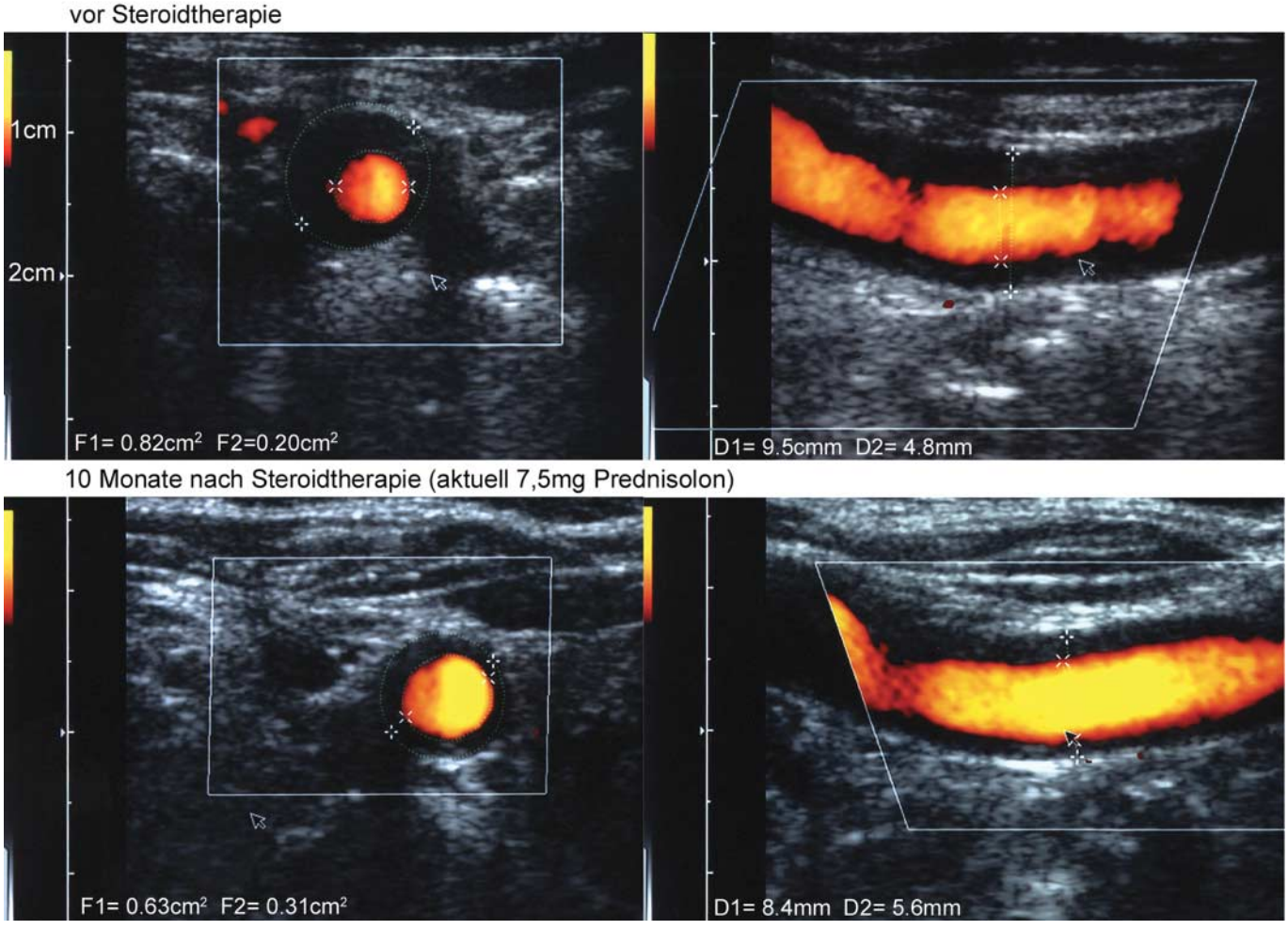

Fig. **2** Colour duplex sonography of the left common carotid artery in a 73-year-old patient suffering from arteritis of the left subclavian and axillary artery and left arm-claudication. Above: Cross and longitudinal sections show hypoechogenic mural thickening of the common carotid artery before steroid treatment and (below) a decrease of the abnormalities 10 months after the start of steroid treatment while receiving a daily dose of 7.5 mg of prednisolone.

Abb. **2** Farbdoppler-Sonographie der linken A. carotis communis bei einem 73-jährigen Patienten mit Arteriitis der linken Aa. subclavia und axillaris und Claudicatio des linken Armes. Oben: Quer- und Längsschnitte zeigen echoarme Wandverdickungen der A. carotis communis vor Steroidtherapie und (unten) einen Rückgang der Veränderungen 10 Monate nach Beginn der Steroidtherapie, letztlich mit einer Dosis von 7,5 mg Prednisolon täglich.

through biopsy, these rates were 47% and 8%. In 1 patient with unilateral AION, reversed flow was detected in both periorbital arteries. In this patient, CDS and digital subtraction angiography of the carotid arteries excluded a stenosis of the carotid arteries and biopsy demonstrated active GCA. In 2 patients with normal temporal arteries, DSPA abnormalities indicating GCA were found.

Summarising the ultrasonographic findings of the temporal and periorbital arteries, only 5/25 (20%) NOC-positive patients had normal findings. In 2 patients with NOC, the DSPA findings were the only abnormalities. In 5 patients without NOC, the DSPA abnormalities were associated with anomalies of the temporal arteries (n = 4) and the common carotid artery (n = 1).

Patients with other illnesses

Colour duplex sonography of the temporal arteries was abnormal in 2 of the 23 patients (9%). In 1 patient with a unilateral occlusion of the central retinal artery and the final diagnosis of Waldenström's disease, a bilateral halo of the common trunk of the STA without stenosis was found, whereas biopsy showed arteriosclerosis.

In another patient with generalised arteriosclerotic disease and unilateral AION, bilateral halos were detected in the STA. In this patient, biopsy also showed severe arteriosclerosis.

Carotid arteries were abnormal in 21 (91%) patients including 7 patients (30%) with stenoses exceeding 50%, (including 1 patient with an ICA and ECA stenosis).

DSPA: No patient had abnormalities typical of GCA.

Discussion

1. Our data from a hospital based cohort of GCA patients show higher rates of abnormal DSPA findings and halos in combination with stenoses in the temporal arteries in patients with NOC. This suggests a more severely disturbed haemodynamic situation in NOC-positive GCA patients.
2. Typical ultrasonographic findings in the temporal and periorbital arteries clearly help to distinguish between arteritic and nonarteritic NOC. Colour duplex sonography of the temporal arteries showed by far the highest rates (72%) of typical abnormalities in the GCA patients followed by DSPA in GCA patients with neuroophthalmological complications (40%).
   In accordance with other studies [17, 18, 20], a low rate (9%) of false positive halos of the STA was found in the non-GCA patients. In contrast to this, no false positive abnormalities typical of GCA were found by DSPA in these patients.
   The most significantly different finding in the GCA patients with and without NOC was the 40% rate of abnormal DSPA findings in the NOC patients. In another study including 27 biopsy-proven GCA patients, DSPA abnormalities were found in two thirds of the NOC-positive patients [12]. The prevalence of CDS/STA abnormalities was similar in both GCA groups except for the higher rate of halos in combination with stenoses.
3. Clinical, arteriographic and autopsy studies have demonstrated the involvement of the carotid arteries by GCA in up to 19% of the 166 patients studied [27]. In our study, however, hypoechogenic concentric mural thickening of the proximal segment of the common carotid artery was only found in 1 patient without NOC. Carotid arteriosclerotic disease was not different in the 3 groups. Stenoses of > 50% were more frequently found in the non-GCA patients with NOC, most likely due to more severe arteriosclerotic disease.

Conclusion

In a substantial number of patients (35% of our cases) finally diagnosed with GCA, biopsy results are unavailable or inconclusive. Colour duplex sonography of the superficial temporal and carotid arteries and Doppler sonography of the periorbital arteries are complementary methods and should be part of the evaluation of all patients suspected to suffer from giant cell arteritis. In experienced hands, ultrasonography is a valuable tool in the non-invasive diagnosis of GCA. CDS of the temporal arteries clearly contributes to the diagnosis of GCA with a high rate of halo and stenosis and can help in the selection of temporal artery segments for biopsy. CDS cannot ultimately differentiate between inflammatory and degenerative artery disease and has limitations of spatial resolution. In contrast to biopsy, ultrasonography allows full length visualisation of the STA and follow-up studies to explore the response to steroid treatment. Doppler sonography of the periorbital arteries shows a high rate of abnormalities and is particularly helpful in GCA patients with neuroophthalmological complications. At present, US cannot replace biopsy in all patients. In patients with typical CDS findings in the STA and involvement of other cranial arteries like the occipital and periorbital arteries, performing a biopsy is not obligatory. In these patients, the response of clinical symptoms, serum markers of inflammation and ultrasonographic abnormalities to adequate steroid treatment can be taken as diagnostic confirmation.

References

[1] Wilkinson IMS, Russell RWR. Arteries in the head and neck in giant cell arteritis: A pathological study to show the pattern of arterial involvement. Arch Neurol 1972; 27: 378 – 387
[2] McDonnel PJ, Moore GW, Miller NR. Temporal arteritis. A clinicopathologic study. Ophthalmology 1986; 93: 518 – 530
[3] Ho AC, Sergott RC, Regillo CD et al. Colour Doppler hemodynamics of giant cell arteritis. Arch Ophthalmol 1994; 112: 938 – 945
[4] Hunder GG, Bloch DA, Michel BA. The American College of Rheumatology 1990 criteria for the Classification of giant cell arteritis. Arthritis Rheum 1990; 33: 1122 – 1128
[5] Dany F, Liozon F, Chaumont P. Sensibilite et specificite du Doppler temporal dans la maladie de Horton. J Mal Vascul 1989; 14: 104 – 105
[6] Dömberger V, Dömberger G, Rössler R et al. Dopplersonographie in der Diagnostik und Therapie der Arteriitis temporalis. Med Welt 1987; 38: 1302 – 1308
[7] Grobe T, Schönherr W. Ultraschall-Dopplersonographie der A. supratrochlearis bei Arteriitis temporalis. Dtsch Med Wschr 1982; 107: 502 – 503
[8] Kelley JS. Doppler ultrasound flow detector used in temporal artery biopsy. Arch Ophthalmol 1978; 96: 845 – 846
[9] Barrier J, Potel G, Renault-Hovasse H et al. The use of Doppler flow studies in the diagnosis of giant cell arteritis. JAMA 1982; 248: 2158 – 2159

[10] Bettelheim H, Grabner G, Haddad R. Doppler-Ultrasonographie der Orbitalen Gefäße bei Arteriitis temporalis. Albrecht v. Graefes Arch klin exp Ophthal 1978; 207: 21 – 26
[11] Vinckier L, Hatron PY, Gadenne C. Interet du Doppler arteriel dans la maladie de Horton. Etude prospective de 59 observations. J Mal Vascul 1989; 14: 116 – 122
[12] Brunholzl C, Müller HR. Doppler sonography fiindings in arteritis temporalis. Ultraschall Med 1988; 9: 232 – 236
[13] Puechal X, Chauveau M, Menkes CJ. Temporal Doppler-flow studies for suspected giant cell arteritis. Lancet 1995; 345: 1437 – 1438
[14] Schmidt WA, Kraft HE, Vorpahl K et al. Colour Duplex Ultrasonography in the diagnosis of temporal arteritis. N Engl J Med 1997; 337: 1336 – 1342
[15] Le Sar CJ, Meier GH, DeMasi RJ et al. The Utility of colour duplex ultrasonography in the diagnosis of temporal arteritis. J Vase Surg 2002; 36: 1154 – 1160
[16] Schmidt WA, Gromnica-Ihle E. Duplex Ultrasonography in temporal arteritis. Ann Int Med 2003; 138: 609
[17] Salvarani C, Silingardi M, Ghirarduzzi A et al. Is duplex ultrasonography useful for the diagnosis of giant-cell arteritis? Ann Intern Med 2002; 137: 232 – 238
[18] Nesher G, Shemesh D, Mates M et al. The predictive value of the Halo sign in colour Doppler ultrasonography of the temporal arteries for diagnosing giant cell arteritis. J Rheumatol 2002; 29: 1224 – 1226
[19] Lauwerys BR, Puttemanns T, Houssiau FA et al. Colour Doppler sonography of the temporal arteries in giant cell arteritis and polymyalgia rheumatica. J Rheumatol 1997; 24: 1570 – 1574
[20] Venz S, Hosten N, Nordwald K et al. Einsatz der hochauflösenden Farb-Doppler-Sonographie in der Diagnostik einer Arteriitis temporalis. Fortschr Röntgenstr 1998; 169: 605 – 608
[21] Schmidt WA, Natusch A, Möller DE et al. Involvement of peripheral arteries in giant cell arteritis: A colour Doppler sonography study. Clin Exp Rheumatol 2002; 20: 309 – 318
[22] Reinhard M, Schmidt D, Hetzel A. Colour-coded sonography in suspected temporal arteritis-experiences after 83 cases. Rheumatol Int 2004; 240: 340 – 346
[23] Pfadenhauer K, Weber H. The contribution of duplexsonography of the temporal and occipital artery in the diagnosis of temporal arteritis. Results of a prospective study in 67 biopsy controlled patients. J Rheumatol 2003; 30: 2177 – 2181
[24] Pfadenhauer K, Weber H. Giant cell arteritis of the occipital arteries. A prospective colour coded duplex sonography study in 78 patients. J Neurol 2003; 250: 844 – 849
[25] Karassa FB, Matsagas MI, Schmidt WA et al. Meta-analysis: Test Performance of ultrasonography for giant-cell arteritis. Ann Intern Med 2005; 142: 359 – 369
[26] Widder B, v Reutern GM, Neuerburg-Heusler D. Morphologische und Dopplersonographische Kriterien zu Bestimmung von Stenosierungsgraden an der A. carotis interna. Ultraschall 1986; 7: 70 – 75
[27] Caselli RJ, Hunder GG, Whisnant JP. Neurologie disease in biopsy proven giant cell (temporal) arteritis. Neurology 1988; 38: 352 – 359