Recommendations for documentation of neurosonographic examinations

The documentation of ultrasound examinations is subject to a dynamic development – particularly as regards newer applications. The present recommendations shall therefore be regularly updated and presented in the internet (http://www.degum.de and www.dkgn.de). Members of DEGUM/DGKN and interested colleagues are expressly invited to contribute comments and suggestions for change (neurologie@bkh-guenzburg.de).

1. General principles

In daily routine diagnostics of the arteries supplying the brain, a considerable part of the questions can be answered reliably using simple and reasonably priced Doppler and gray scale duplex devices. These methods are therefore still recommended for practical and clinical use and are helpful for cost-efficient patient care. However, in order to cover the entire diagnostic spectrum of neurological ultrasound diagnostics according to the quality requirements of the DEGUM/DGKN certificate, the combined use of Doppler and colour-coded duplex sonography with duplex probes of different frequencies and specific accessories (e.g. fixed monitoring probes) is indispensable. Therefore, the presented documentation standards refer to this combined use only. Applications of Doppler sonography alone should continue to be documented according to the established DEGUM standards.
Image and graph documentation is an essential part of quality assurance in neurological ultrasound diagnostics. It is intended to inform on the appropriate selection of the examination procedures used, the adequate performance of the examination and the correct evaluation. Therefore, the documentation must be as comprehensive and clear as is necessary to make the sonographic findings comprehensible. In non-pathological cases, “basic documentation” is sufficient. As a rule for pathological cases, any findings described as abnormal and contributing to diagnosis must be documented. Furthermore, in case of special questions, the specific requirements of the examination must be considered both during the examination and in the documentation.
Due to the often considerable data, particularly from colour-coded duplex sonography, it is recommended to store the data on electronic media (e.g. MOD drive, video tape). But it must be possible to make reproductions that permit quality control through third parties without using additional optical and/or electronic devices. The graph and image documentation as well as the description and evaluation of the findings must be archived. Transmitting images to transferring physicians or co-doctors or to the patients, if applicable, should not compromise the institution’s own image documentation.

2. Device-specific documentation

Unless applicable legal regulations (e.g. in case of treatment of health insurance patients) provide separate documentation, each vessel examined using preferably the combination of Doppler and duplex sonography should be documented with that method that provides best diagnostic information in the concrete examination situation [1]. An exception of this requirement is the training to prepare for the DEGUM/DGKN certificate for which the required 200 extracranial examinations should be documented to the extent technically possible with both Doppler and duplex sonography to provide for comprehensive training.
Independent of the vascular region examined, the following aspects should be considered for documentation:
Doppler sonography: The documentation of the frequency-time spectrum is required over a number of cardiac actions that is considered appropriate for the individual case [2] with indications of the Doppler shift scale and the ultrasound transmitter frequency used. Automatic display of the maximum systolic and end-diastolic Doppler shift and the intensity-weighted mean Doppler shift (mean) is recommended. Recording the mean value is mandatory for certain questions [3]. It is not sufficient to present the analogue-pulse curve using a zero-crossing counter as is used in more simple Doppler devices or to do a merely numerical evaluation of parameters of the Doppler spectrum. It must be indicated in the documentation what vessel and what side was examined (e.g. “RICA” for right internal carotid artery).
Cross-sectional sonography: Unless the region or vascular portion of interest can be identified easily in the cross-sectional image because of typical landmarks (e.g. carotid bifurcation, clivus with pons), the documentation should include a corresponding description (e.g. pictographs) indicating the side examined. Important examination parameters (e.g. intima-media thickness or ventricular width) must be measured concretely and noted in the image.
Colour-coded duplex sonography: The findings must be documented in a colour-coded way, preferably as a combination of cross-sectional image and Doppler spectrum. Unless vascular structures can be identified easily in the gray scale cross-sectional image (e.g. in case of transcranial sonography), colour-coding must be used. Longitudinal sections through a vessel (e.g. the common carotid artery) must be documented in the (colour-coded)

cross-sectional image in a way that enables visualisation of the vascular portion as a ribbon, if possible over the entire screen.

3. Basic documentation (minimum requirements)

3.1 Extracranial Doppler/duplex sonography

The minimum requirements in non-pathological cases include continuous sonographic detection of the following vascular structures for comparison of both sides and documentation using the method providing the best information for the individual case:

	Doppler sonography	**Duplex sonography**
Terminal branches of the ophthalmic artery	Supratrochlear artery	Vessels in the medial canthus and/or central artery of the retina
Common carotid artery	Selected points [4]	Longitudinal section with Doppler spectrum [5]
Internal carotid artery	Selected points [4]	Bifurcation of the common carotid artery into the internal carotid artery with Doppler spectrum of the internal carotid artery [5, 6.1] and distal internal carotid artery
External carotid artery	Selected points [4]	Bifurcation of the common carotid artery into the external carotid artery with Doppler spectrum of the external carotid artery [5, 6.1]
Vertebral artery	Atlas loop or origin from the subclavian artery [4]	Intravertebral course (V2 segment) with Doppler spectrum and diameter determination [5, 6.1]
Subclavian artery	Proximal portion [4]	-

Since the systolic maximum frequency is the most important criterion as regards diagnostics, the Doppler spectrum with the highest detectable systolic frequency or blood flow velocity should be documented for each vascular portion. If duplex sonography is used, the examination should always include, if technically possible, the angle-corrected determination of the blood flow velocity (insonation angle < 60° if possible).
In order not to forget individual vascular structures during the examination and to avoid problems with later labelling of vascular portions, it is recommended to use a standardised course of examination (e.g. at first comparison of the supratrochlear arteries of both sides, then left/right neck with carotid branches, vertebral and subclavian arteries).
If the duplex images are not stored digitally, the colour-coded documentation with the video printer may be restricted, for reasons of costs, to such non-pathological cases where the course of the vessel is not sufficiently visible in black-and-white documentation and the coloured image contributes substantially to the quality of evaluation. A general restriction to colour-coded imaging of vascular structures without additional blood flow information in the Doppler spectrum must be rejected since this would permit seriously false evaluations.

3.2 Transcranial Doppler/duplex sonography

The minimum requirements in non-pathological cases include continuous sonographic detection of the following vessels (with exception of the basilar artery) for comparison of the sides and documentation with the method providing the best information in the individual case:

Transtemporal	Doppler sonography Recommended insonation depth	Duplex sonography
· Middle cerebral artery	45-55 mm	Colour-coded axial section with Doppler spectrum of the M1 segment [6.1]
· Anterior cerebral artery	70-75 mm	Colour-coded axial section with Doppler spectrum of the A1 segment [6.2]
· Posterior cerebral artery	70-75 mm	Colour-coded axial section with Doppler spectrum of the P1 or P2 segment [6.2]
Transnuchal	Doppler sonography Recommended insonation depth	Duplex sonography
· Vertebral artery	65-75 mm	see below
· Basilar artery	as cranial as possible	Colour-coded visualisation of the vertebrobasilar junction with Doppler spectrum of the basilar artery [6.2]

4. Case-related documentation (recommendations)

The following information includes recommendations for documentation that may be helpful to answer relevant clinical questions in pathological cases or for the specific exclusion of a pathology. Here, documentation is used to record sonographic findings for third parties in a comprehensible way. Evaluation-related documentation is always done **in addition to basic documentation**. Quite rare findings (e.g. stenoses of the common carotid artery) that are not explicitly mentioned must be documented in an analogous way.

	Documentation in addition to basic documentation	
EXTRACRANIAL	**Extracranial Doppler/duplex**	**Transcranial Doppler/duplex** [7]
Stenosis of the internal carotid artery, extracranial part	Region of the maximum stenosis in two planes (e.g. longitudinal and cross sections) as well as – if technically possible – a longitudinal section of the post-stenotic portion that is most distal from the stenosis. Blood flow spectrum for each case with determination of the maximum blood flow velocity and, as far as relevant for stenosis grading, documentation of post-stenotic blood flow disorders. Post-stenotically, also diameter determination if diameters differ in the comparison of both sides (e.g. dissections), flow volume determination if necessary	In case of higher-grade stenoses and occlusions, in addition to the transcranial basic examination, assessment of the intracranial collateral pathways if necessary (if therapeutic consequences must be expected, a carotid compression test may be included in individual cases [8]), of the ophthalmic artery if necessary (transorbital sonography) and of the cerebrovascular reserve capacity if necessary
Occlusion of the internal carotid artery, extracranial part	Visualisation of the occluded vascular portion in colour duplex with low-flow settings [9] in two sectional planes	
Occlusion of the common carotid artery	Longitudinal section of the occluded vascular portion in colour duplex with low-flow settings [9] and visualisation of the internal and external carotid arteries	
Abnormal course of the extracranial portions of the carotid artery (e.g. kinking)	Abnormal course of the vessel in the longitudinal section; in case of kinking, sonographic detection of blood flow velocity immediately before, at the maximum of and immediately after the kinking site	Basic documentation
Vertebral artery (hypoplasia, aplasia, stenoses, occlusions)	As far as technically possible, all portions of the vertebral arteries (V0-V3) of both sides including diameter determination and blood flow spectrum with determination of the blood flow velocity; in case of stenoses, visualisation of the maximum stenosis and post-stenotic course	Course of the vertebral artery (V4) until it runs into the basilar artery with spectrum analysis of the vertebral arteries and the basilar artery
Subclavian artery (stenoses, occlusions)	Comparison of the subclavian arteries of both sides in the proximal and distal portions, vertebral artery with brachial compression test	Vertebral artery (V4) and basilar artery, with brachial compression test if necessary

Unless comprehensive colour-coded documentation is urgently required (transcranial duplex sonography) and data will be stored on electronic media anyway, colour-coded duplex documentation with the video printer may be restricted, for reasons of costs, to those cases where the colour image contributes substantially to demonstrate the findings more clearly to potential secondary evaluators. This applies regularly to stenoses with low-echo wall signals that are not clearly circumscribed in the cross-sectional image and to cases of irregular courses of vessels (e.g. kinking, coiling, dissection) and, of course, to glomus tumours and for distinguishing filiform stenoses from occlusions.

	Documentation <u>in addition</u> to basic documentation	
INTRACRANIAL **[10]**	**Extracranial Doppler/duplex**	**Transcranial Doppler/duplex [11]**
Stenosis/occlusion of the internal carotid artery, intracranial part	In case of differing diameters when comparing the sides (e.g. dissections), flow volume determination if necessary	In case of stenoses – as far as technically possible –, visualisation of maximum stenosis and post-stenotic course (also transorbital if necessary), evaluation of the intracranial collateral pathways
Carotid T occlusion		Detection of a sufficient temporal acoustic window by visualising the contralateral anterior cerebral artery and the top of the basilar artery together, supported by signal enhancers if necessary
Stenosis of middle cerebral artery	Basic documentation	As far as technically possible, middle cerebral artery before, at the maximum of and after the stenosis with blood flow velocity
Occlusion of middle cerebral artery (M1 segment)	Comparison of the internal carotid arteries of both sides with blood flow spectrum, preferably with flow volume	Detection of a sufficient temporal acoustic window by visualising the ipsilateral anterior and posterior cerebral arteries together, supported by signal enhancers if necessary
Stenosis of the basilar artery	Vertebral artery in the region of the atlas loop (V3) in addition to basic documentation	As far as technically possible, basilar artery before, at the maximum of and behind the stenosis
Occlusion of the basilar artery	Basic documentation of both vertebral arteries	Not usable in most pathological cases; colour-coded visualisation of the vertebrobasilar junction with Doppler spectrum of the vertebral arteries (V4) and the basilar artery, supported by signal enhancers if necessary, to exclude an occlusion of the basilar artery. Transtemporal visualisation of the top of the basilar artery with the posterior cerebral arteries and, if necessary, the posterior connecting branches

5. Documentation of special topics

The following information is intended to help not only in documentation but also to answer special questions in neurological ultrasound diagnostics. It refers to new, not yet standardised and not generally common applications. As soon as new scientific results are obtained, the recommendations will be modified and amended.

5.1 Syncope

Technical requirements: transcranial Doppler sonography with probe fixed to the head, device for automatic blood pressure measurement (continuous or intermittent), tilt table

Course of examination: continuous Doppler sonographic detection of the middle cerebral artery of one or both sides. At the same time measurement of blood pressure and pulse, continuously (e.g. Finapres device) or intermittently every 30 s. After 5-10 minutes in a relaxed supine position, the patient will be tilted in a vertical position and sonography is performed for 10-15 minutes.

Documentation: documentation of mean value or mean maximum Doppler shift, blood pressure and pulse during the entire examination, either continuously or intermittently every 30 s.

5.2 Micro-emboli detection

Technical requirements: transcranial Doppler sonography with probe fixed to the head. Doppler device with FFT overlapping > 50%, a wall filter as low as possible (< 100 Hz), low axial measurement volume (4-10 mm) and low-level dynamic range.

Course of examination: continuous sonographic detection of arteries of the cerebral circle for generally 60 minutes (may be shorter for restless patients) with continuous audiovisual assessment of the Doppler spectrum or use of semiautomatic embolus detection (e.g. threshold detector) with subsequent evaluation. The examination may be stopped after shorter detection times if at least 3 micro-emboli were detected.

Documentation: all signals in the Doppler spectrum potentially indicating micro-emboli over at least one cardiac cycle

5.3 Detection of right-to-left shunts
Technical requirements: transcranial Doppler sonography, preferably bilateral sonography with probes fixed to the head. A minimum of 2x5 ml of commercially available ultrasound contrast medium (e.g. Echovist) or maybe also "agitated" saline solution containing micro air bubbles (warning: not approved for use in Germany).
Course of examination: continuous sonographic detection of the middle cerebral artery after at least two i.v. administrations of contrast medium of 5 ml each in the bolus. The first run always includes a Valsalva manoeuvre approx. 5 s after start of injection; no Valsalva is performed in the second run if a relevant number of bubbles could be detected in the first run already.
Documentation: continuous monitoring of the Doppler spectrum during the first 45 s after the administration of the contrast medium with low signal enhancement. Continuous documentation (e.g. video or digital medium) or, at least, printout of a relevant screen content. Documentation of the time points of the administration of the contrast medium and of the Valsalva manoeuvre. Semiquantitative documentation of the detected appearance of the contrast medium (for unilateral sonography < 10, > 10 bubbles, "shower").

5.4 Cerebrovascular reserve capacity

5.4.1 Apnoea test
Technical requirements: transcranial Doppler sonography, preferably bilateral, with probe fixed to the head.
Course of examination: continuous sonographic detection of the Doppler spectrum of arteries of the cerebral circle, initially during approx. 30 s of strong hyperventilation followed by approx. 30 s holding the breath and approx. 30 s of normal breathing.
Documentation: continuous documentation of the Doppler spectrum, or the mean value, or the mean maximum Doppler shift, alternatively registration of a screen content of the 3 situations (i.e. normocapnia, hypocapnia and hypercapnia) approx. 5 s after the end of holding the breath

5.4.2 Acetazolamide test
Technical requirements: transcranial Doppler sonography, preferably bilateral, with probe fixed to the head.
Course of examination: continuous sonographic detection of the Doppler spectrum of arteries of the cerebral circle starting at the i.v. injection of acetazolamide (Diamox^R, dosing usually depending on body weight: 15 mg/kg body weight) for a maximum period of 20 minutes.
Documentation: continuous documentation of the Doppler spectrum, or the mean value, or the mean maximum Doppler shift, alternatively registration of a screen content at the beginning and then every 5 minutes.

5.4.3 CO_2 test
Technical requirements: transcranial Doppler sonography, preferably bilateral, with a probe fixed to the head, measuring device to determine the end-expiratory CO_2 concentration of the respiratory air (capnometer), option to increase the pCO_2 of the respiratory air (e.g. gas mixing valve, carbogen gas).
Course of examination: continuous sonographic detection of the Doppler spectrum of the arteries of the cerebral circle as well as the end-expiratory CO_2 concentration of the respiratory air at rest, during 2 minutes of hypercapnia and then during 1 minute of slight hyperventilation.
Documentation: preferably continuous documentation of the mean value or the mean maximum Doppler shift and of the end-expiratory CO_2, in form of a diagram of CO_2 concentration in relation to blood flow velocity if necessary. Alternatively, registration of a screen content at the end of each of the three examination phase situations.

5.5 Vasospasms (e.g. in subarachnoidal haemorrhage)
Technical requirements: extracranial and transcranial Doppler or duplex sonography
Course of examination: sonographic detection of the extracranial internal carotid artery (for the MCA-ICA index) and middle cerebral artery for comparison of the sides, and also of anterior and posterior cerebral arteries for follow-ups.
Documentation: Doppler spectrum of all sonographically detected vessels with particular consideration of the systolic maximum frequency as the most reliable parameter.

5.6 Brain death (arrest of the cerebral circulation) (chapter in preparation)

5.7 Sonography in acute stroke of the anterior cerebral circulation
Technical requirements: extracranial and transcranial duplex, supplemented by Doppler if necessary (e.g. supratrochlear artery)
Course of examination: colour-coded visualisation of the ipsilateral internal carotid artery and middle cerebral artery with Doppler spectrum, supported by signal enhancers if necessary. In case of a suspected proximal occlusion of the middle cerebral artery, colour-coded visualisation of the other ipsilateral and contralateral arteries of the cerebral circle in the same acoustic window. In case of a suspected distal occlusion of the middle cerebral artery or

its branches, angle-oriented determination of the blood flow velocity in the proximal middle cerebral artery. In case of unclear situations, also sonographic detection of the supratrochlear artery and the common carotid artery comparing the two sides.
Documentation: colour-coded documentation of the examined vessels, Doppler spectrum of the internal carotid artery and the middle cerebral artery (if not occluded).

5.8 Sonography in acute stroke of the posterior cerebral circulation (chapter in preparation)

6. Report

Every report should include a unique patient identification, the examination date, the question or tentative diagnosis leading to the sonographic examination and the signature of the physician performing the examination. It should be divided into two parts:

6.1 Description of the findings
The findings may be described either in a text or in a graph using a scheme (table of vessels and/or vascular anatomy). If signal quality or visualisation is compromised, this must be recorded as must be particular problems arising during the examination. In case of abnormal findings, the results must be described in detail; if the findings are non-pathological, it is sufficient to note "NAD" or "unremarkable".
Doppler spectrum: pathological findings must be documented using direct and indirect criteria – including the systolic maximum frequency or the angle-corrected blood flow velocity for stenosis grading. Furthermore, reactions to compression tests must be described. If a pathology is found during transcranial sonography, the selected access and the relevant examination depth must also be documented.
(Colour-coded) cross-sectional image: any changes in the vessel walls that are visible in the (colour-coded) cross-sectional image must be characterised for location, extension, structure and surface. In addition, any deviations of lumen, course and pulsation from the standards must be documented.

6.2 Evaluation of the findings
This includes a written summarised evaluation of the sonographic findings with a statement referring to the question. In non-pathological cases, a short summary is sufficient.
[1] Typical examples are:
a) The terminal branches of the ophthalmic artery can generally be evaluated most easily and reliably with the cw-Doppler probe (supratrochlear artery). The sonographic detection of the central artery of the retina with the duplex probe requires comparatively more efforts.
b) While the cw-Doppler probe can only be used for punctiform sonographic detections in the junction area and at the atlas loop, the entire course of the vertebral artery including its diameter can regularly be evaluated using duplex sonography.
c) Despite the improvements of the duplex technology during the last few years, individual cases of intracranial vessels with an insufficient temporal acoustic window can sonographically be detected more reliably with the cw-Doppler probe.
[2] Some few cardiac actions are sufficient to record stenoses. For provocation manoeuvres (e.g. compression tests), the situation with and without the provocation should be visible in the same evaluation.
[3] e.g. determination of the cerebrovascular reserve capacity, evaluation of vasospasms
[4] continuous sonographic detection of the course with registration of the Doppler spectrum of selected points with the highest detectable systolic frequency in each case
[5] as far as technically possible, always with angle-corrected measurement of the maximum systolic blood flow velocity. If the systole cannot be visualised on the screen for technical reasons, the maximum end-diastolic blood flow velocity must be measured.
[6.1] This can be documented, mainly in non-pathological cases, in a combined image (longitudinal section with or without colour-coding and Doppler spectrum with angle-corrected calculation of the maximum systolic blood flow velocity) if the visualisation of the vessel is ensured to have a scale of at least 1:1
[6.2] as far as technically possible, always with measurement of the maximum systolic blood flow velocity
[7] supported by signal enhancers if necessary
[8] A short-term carotid compression can only be recommended if duplex sonography ensures that there are no plaques in the compression area and if the compression area is clearly below the carotid bifurcation
[9] low pulse repetition frequency, low wall filter, high colour enhancement, reduction of persistence (correlation) if necessary, power mode if necessary, supported by signal enhancer if necessary
[10] In case of pathological intracranial vascular processes, an extracranial ultrasound examination (with the relevant documentation) is mandatory
[11] supported by signal enhancers if necessary