Influence of Contralateral Obstructions on Doppler-Frequency Spectral Analysis of Ipsilateral Stenoses of the Carotid Arteries

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SUMMARY  Contralateral obstructions have been suggested to be responsible for inaccuracy in Doppler sonographic diagnosis and estimation of severity of internal carotid artery stenoses. Therefore correlations of the systolic peak frequency of the internal carotid artery (Doppler-Frequency-Spectrum-Analysis) and severity of stenoses found by angiography have been compared in subgroups with \( n = 36 \) and without \( n = 48 \) additional contralateral obstructions. The linear regressions in both subgroups were found to be very similar \( (Y = 0.0098X - 12.4 \text{ and } Y = 0.0099X - 14.0) \), the coefficients of correlation identical \( (r = 0.83) \).

In 26 patients, the systolic peak frequency of the internal carotid artery did not demonstrate a significant change due to operation of the contralateral vascular lesion; thus indicating that contralateral obstructions do not influence CW-Doppler sonographic findings of an ipsilateral vessel wall lesion concerning diagnostic accuracy and non-invasive estimation of the severity of stenoses.

THE SYSTOLIC PEAK FREQUENCY of the internal carotid artery measured by means of Doppler frequency spectrum analysis correlates with the severity of stenosis found by angiography. \(^\text{2-6, 8-11, 12}\) Although there is a close statistical correlation between invasive and non-invasive techniques both methods differ considerably in some cases. \(^\text{6}\) The factors influencing non-invasive measurement of blood flow velocities by CW-Doppler spectral analysis have been discussed elsewhere. \(^\text{6, 11}\) Some authors found that contralateral obstructions influence the Doppler ultrasound examination of the ipsilateral internal carotid artery due to collateral blood flow. \(^\text{1, 8, 12}\)

The purpose of our study was to prove if contralateral obstructions influence the Doppler ultrasound examination of the ipsilateral internal carotid artery. We used two different accesses for our investigations: 1. Our study was designed as an interindividual study and compared the coherence of the grade of stenosis found by angiography and the systolic peak frequency measured by means of Doppler spectrum analysis in unilateral lesions as well as in bilateral lesions of the internal carotid artery. 2. In addition we performed an intra-individual examination in patients who underwent reconstructive surgery of the internal carotid artery. In these patients we studied the contralateral vessel prior to and after surgical intervention.

Material and Methods

Materials used included CW directional Doppler ultrasound device (Type 762 Kranzbühler/Solingen, Germany) \( 4 \text{ MHz transducer and a doppler frequency spectrum analyzer (FFT)} \) (Type 8106 Kranzbühler/Solingen, Germany frequency range \( 0-2, 0-4, 0-8 \text{ and } 0-16 \text{ KHz respectively}} \), frequency resolution due to 80 channels \( 25, 50, 100 \text{ and } 200 \text{ Hz respectively}} \), signal duration \( 1.25 \text{ or } 2.5 \text{ sec}\); and with a cursor the systolic peak of the frozen spectrum was measured and displayed in Hz). A systolic peak frequency of the internal carotid artery exceeding \( 3500 \text{ Hz} \) was considered to be indicative of a stenosis.

The methods concerning examination and differentiation of the common, external and internal carotid artery have been described elsewhere. \(^\text{5-7}\)

Patients

Inter-Individual Study

We studied 20 patients suffering from an unilateral stenosis of the internal carotid artery. The vessel diameter reduction reached from 40 to 97% angiographically. In addition, 16 patients with normal carotid arteries proved by angiography have been examined, too. This group \( (n = 36 \text{ patients}) \) was compared to a second group \( (n = 48 \text{ patients}) \) in whom there was a higher degree lesion of the contralateral vessel. This group consisted of 14 patients suffering from stenoses of the internal carotid arteries with from 14 to 92% vessel diameter reduction accompanied by a contralateral complete occlusion and 18 patients with stenoses from 8 to 67% vessel diameter reduction accompanied by a higher degree lesion of the contralateral vessel. In addition there were 16 patients in this group in whom there was a normal carotid artery and different grades of stenotic lesions of the contralateral vessel.

Intra-Individual Study

In 26 patients who underwent surgery of an extracranial carotid artery stenosis the systolic peak frequency of the contralateral internal carotid artery was measured pre- and postoperatively, as well. While 6 patients suffered from an unilateral stenosis, bilateral strike was found in 20 patients.

Results

Inter-Individual Study

In the group of patients with a normal contralateral carotid artery we found a close correlation of vessel diameter reduction and the systolic peak frequency of the internal carotid artery: \( y = 0.0098x - 12.4 \); coefficient of correlation \( r = 0.83 \) (fig. 1).
In the other group with a more severe lesion of the contralateral carotid artery statistical analysis derived a linear regression of vessel diameter reduction found by angiography and a systolic peak frequency measured by means of Doppler spectrum analysis: \( y = 0.0099 x - 14.0 \); coefficient of correlation \( r = 0.83 \) (fig. 2).

There was no significant difference in coherence of the angiographically measured grade of stenoses and Doppler frequency measurements, when unilateral and bilateral carotid artery lesions were compared. Moreover, we found identical coefficients of correlation.

**Intra-Individual Study**

Student's paired t-test did not demonstrate a significant change of the systolic peak frequencies of the internal carotid artery in patients in whom the contralateral carotid artery was operated on: The systolic peak frequency was 5442 ± 2727 Hz and 5229 ± 2687 Hz pre- as well as postoperatively; \( t = 1.33 \).

The values — pre- and postoperatively measured — were situated in the neighborhood of the line of identical values: \( y = 0.97 x + 377; r = 0.95 \), thus indicating that contralateral obstructions did not influence Doppler ultrasound examination of the ipsilateral carotid artery (fig. 3).

**Discussion**

Our study shows that there is no significant difference in the coherence of the systolic peak frequency and the severity of stenosis measured angiographically when comparing unilateral and bilateral carotid artery disease. Moreover, after removal of a contralateral hemodynamic significant lesion, a decrease in the systolic peak frequency of the ipsilateral internal carotid artery could not be demonstrated. This indicates that contralateral obstructions do not influence CW-Doppler sonographic findings of an ipsilateral vessel wall lesion and do not reduce the diagnostic accuracy of non-invasive estimation of the severity of stenoses.

Therefore false-positive findings by Doppler sonography must have other reasons. The criterion of a low grade stenosis so far is an increase of the Doppler shift frequency. However an increase of the amplitude in the Doppler signal may mimic an increase of frequency and can be misinterpreted by acoustic control.13

We believe that contralateral obstructions are not responsible for non-invasive overestimation of the severity of an ipsilateral internal carotid artery stenosis.6,8,12 Our findings seem to be contradictory to the theory of collateral blood flow in extracranial carotid artery disease. Yet, we did not measure blood flow volumes. The systolic peak frequency of the CW

![Figure 1. Correlation of the severity of stenoses — reduction of vessel wall diameter — and the systolic Doppler peak frequency in patients with normal contralateral carotid arteries.](image1)

![Figure 2. Correlation of the severity of stenoses as demonstrated by angiography and the systolic peak Doppler frequency in patients with a higher degree lesion of the contralateral internal carotid artery.](image2)

![Figure 3. The systolic peak frequency of the contralateral internal carotid artery in patients, who underwent carotid artery surgery of the other side. \( n = 26 \). The line of identical values \( y = x \) is figured.](image3)
Doppler frequency spectrum displays a qualitative measure of the blood flow velocity, only. In contrast to blood flow volume, blood flow velocity does not depend on vessel wall diameter. Although blood flow velocities — i.e., systolic peak frequencies — are not influenced by contralateral obstructions, (collateral) blood flow volume may increase due to dilatation of vessel diameter.

References

Non-Invasive Diagnosis of Intracranial Lesions in the Vertebrobasilar System. A Comparison of Doppler Sonographic and Angiographic Findings

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SUMMARY The accuracy and the reliability of extracranial vertebral Doppler flow (continuous wave Doppler sonography) for the detection of intracranial vertebrobasilar lesions was studied prospectively in twenty-one patients with brainstem disturbances and/or coma. The Doppler findings were compared with cerebral angiography. Doppler sonography was highly reliable for both detection and exclusion of high-grade intracranial vertebrobasilar lesions. The pathognomonic Doppler finding was an abrupt deceleration of the blood column during systole and stoppage or even reflux during diastole. The same blood flow alterations were found in two additional illustrative cases having therapeutically or brain-death induced blockages of the vertebral arteries. The pathophysiological mechanisms of flow disturbances and the limitations of Doppler sonography in this area are discussed.

THE INTRADURAL PART OF THE HINDBRAIN ARTERIES can be viewed as a functional entity. Thompson et al (1979) coined the term “intradural vertebrobasilar artery.” This arterial segment is the most critical part of the hindbrain vascular system when considering the severity of neurological deficits following occlusive lesions. The closer the vascular lesion is located to the brain the more crucial it is for an impaired cerebral blood supply.2,3 Several non-invasive diagnostic techniques have been applied to the vertebrobasilar system with limited success.4-9 However, recent experiences with Doppler sonography in the atraumatic diagnosis and followup of patients with thrombosis of the distal vertebrais or basilar (i.e., intracranial vertebrobasilar system) have been encouraging.10,11 The following report describes the clinical, Doppler sonographic and angiographic findings in 21 patients. It was presumed on admission that these subjects suffered from intracranial thrombosis of the vertebrobasilar artery. Clinical and laboratory findings will be compared to define the diagnostic value of CW-Doppler sonography for intracranial occlusive vertebrobasilar disease.

Methods
Doppler Sonography
Using a continuous wave Doppler device with a probe emitting 4 MHz ultrasound (Delalande D 800)
Influence of contralateral obstructions on Doppler-frequency spectral analysis of ipsilateral stenoses of the carotid arteries.

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