TRANSCRANIAL DOPPLER FINDINGS IN A PHASIC PATIENTS WITH CAROTID ARTERY STENOSIS OR OCCLUSIONS

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ABSTRACT

Introduction. Aphasia is present in 21-38% of acute ischaemic stroke individuals, being associated with short – and long-term morbidity and mortality, and can have a dramatic impact on person's ability to communicate. A cerebro-vascular diagnostic examination is considered part of the standard work-up after cerebral ischaemia. However, only scarce data exist on the distribution steno-occlusive diseases in patients (pts) with aphasia. Transcranial Doppler (TCD) is a useful noninvasive method of intracranial circulation assessement. We wanted to investigate the role of TCD in determination of abnormalities affecting intracranial, and/or extracranial parts of vessels supplying the brain in aphasics with acute ischemic stroke.

Patients and methods. A total of 166 patients (pts) with the first acute ischaemic stroke and aphasia were selected between January 2007 and September 2008. Their language function was evaluated by means of the Romanian modified version (Kory Calomfirescu, 1996) of the Western Aphasia Battery – WAB (Kertesz A., 1980). They received Color Duplex Sonography (CDS) and Transcranial Color Duplex Sonography (CDS) examinations in the first 48 hours of onset. There was no history and no brain MRI findings of an earlier stroke.

Results. The main characteristics of aphasics at admission were: N=166, gender F/M=63/103, years (mean +/-SD) = 61.06+/-8.79. The main aphasic syndrom at admission was Broca's aphasia (55%). In 75.3% of cases (125 pts) the lesions were located at classical language centers.

TCSS and CDS results were the following: 1) 65 pts (39.1%) with no changes in the intracranial hemodynamics; 2) 101 pts (60.9%) with the following changes: a) 25 pts (15.1%) with MCA or terminal ICA (C_1) stenosis/occlusions; b) 76 pts (45.8%) with hypoperfusion of the L and/or R MCA. 34 pts of the hypoperfusion aphasics had a significant stenosis/ or occlusion of the extracranial ICA, with collateral circulation (through ACoA, PCoA or OA).

Conclusions:

1. In our study, Broca's aphasia was the most frequent aphasic syndrome in the acute stage of ischemic stroke in the territory of the MCA.
2. The damaged lesions of most aphasics were melted with classical language functional areas; but others sites damaged also could produce aphasia.
3. TCD was an important non-invasive method for the evaluation of the intracranial cerebral vascular diseases and of the intracranial hemodynamic impairment in the extracranial carotid diseases causing post-stroke aphasia.

Key words: aphasia, acute ischemic stroke, steno-occlusive diseases, transcranial Doppler.

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INTRODUCTION

Aphasia represents a loss or impairment of the production and/or comprehension of spoken and/or written language, due to an acquired lesion of the brain. The main aphasic syndromes are: (1) motor, or Broca's aphasia, or "nonfluent" aphasia; (2) sensory, or Wernicke's aphasia, or "fluent" aphasia; (3) total, or global aphasia with loss of all or nearly all speech and language functions; and (4) one of the disconnection language syndromes, such as conduction aphasia. In Broca's aphasia, the patients present a primary deficit in language output, with relative preservation of the comprehension. The speech production is slowly, as compared with the normal, the prosody may be greatly reduced, with significant articulatory disturbances and word/finding difficulties. Repetition and writing are impaired. The clinical picture can evolve towards agrammatism, giving speech a "telegraphic" character. In Wernicke's aphasia, speech is fluent, well articulated, with normal prosody, but lacking meaning, with many paraphasias, and with significant disturbances of language comprehension. These patients present a varying inability to repeat spoken and written words, alexia (an inability to read) and agraphia. (1-7)

More than 95% of right-handed people and even most left-handed people have dominance for speech and language in the left hemisphere (the cerebrum irrigated by the left middle cerebral artery being of prime importance in language function). Right hemisphere dominance for speech and language in a right handed person is distinctly uncommon. (8-9)

Few studies indicated that aphasia is present in 21-38% of acute ischaemic stroke individuals, being associated with short- and long-term morbidity and mortality, and producing a dramatic impact on person's ability to communicate. (10-13) Broca's aphasia is most often due to a vascular lesion, with frontal suprasylvian localisation, especially an embolic infarction (less often atherosclerotic thrombus) in the territory of the upper (rolandic, superior) division of the middle cerebral artery (MCA). In Wernicke's aphasia, the lesion lies in the posterior perisylvian region, and is usually due to embolic (less often thrombotic) occlusion of the lower (inferior) division of the MCA. As a rule, in global aphasia, the lesion is due to occlusion of the left internal carotid artery (ICA), or proximal MCA. (14-19)

A cerebro-vascular diagnostic examination is considered part of the standard work-up after cerebral ischaemia. However, only scarce data exist on the distribution and prognosis of steno-occlusive diseases in patients (pts) with aphasia. Transcranial Doppler (TCD) is a useful noninvasive method of intracranial circulation assessement. (16,17,20)

OBJECTIVES

The study purpose was to investigate the role of TCD in determination of abnormalities affecting intracranial and/or extracranial parts of vessels supplying the brain in aphasics with acute ischaemic stroke.

PATIENTS AND METHODS

1) We selected, between January 2007 and September 2008, a total of 166 pts, who met the following criterias:

a) admission within 24 hours (h) of aphasia onset;
b) 20-75 years of age;
c) native Romanian speakers (Caucasian pts);
d) diagnosis of first acute ischaemic stroke in the territory of the left or right MCA: all pts had at admission a single large (>20 mm diameter) ischaemic lesion. We excluded pts with additional clinical small vessels abnormalities revealed by Flair or T_2-weighted MRI slices.
e) no history of dementia or other psychiatric disorders;
f) bilateral presence of temporal windows at TCD examination.

All 166 pts underwent at admission a carefull medical history, physical examination, routine blood examinations, urine analysis, electrocardiogram, and chest x-rays. A senior neurologist, member of our stroke team, made a neurological examination, independently of Doppler ultrasonography and neuroimagistic results.

Key exclusion criterias were transient ischaemic attacks, pts with incontrollable hypertension, acute myocardial infarction, pts with other severe concomitant diseases (renal or/and hepatic insuffiency).

2) Their language function was evaluated by means of the Romanian modified version (Kory Calomfirescu, S., 1996) (21) of the Western Aphasia Battery-WAB (Kertesz, A., 1980) (22) (table I).

WAB included the assessement of: spontaneous speech (SS); comprehension (C); repetition (R) and naming (N). We have calculated the scores, and we have established at admission an Aphasia Quotient (A.Q.) for each pt.

3) A complete cerebrovascular examination was performed in all cases:

Table 1. *Western Aphasia Battery*

Subscale	*Label in SPSS*	*Maximum score*
Spontaneous speech		
Functional content	SSFC	10
Fluency	SSFL	10
Spontaneous Speech Total		[20]*
Comprehension		
Yes / No questions	CYN	60
Auditory word recognition	CWD	60
Sequential commands	SCO	80
Comprehension Total (Aphasia Quotient)	COMPT	(60+60+80)/20 [10]*
Repetition		
Repetition Total	REP	100/10 [10]*
Naming		
Object naming	OBNA	60
Word fluency	WDFL	20
Sentence completion	SECO	10
Responsive speech	RESP	10
Naming Total	NAMET	(60+20+10+10)/10 [10]*
APHASIA QUOTIENT	**AQ**	Add above totals in [] rows marked by *, then x2

a) all aphasics underwent at admission brain CT scan (Aura Philips spiral single slice). Loss of gray-white differentiation, sulcal effacement, and other early CT changes that have high inter-rater variability were not exclusion criterias.

In the following 24 h they received:

b) Magnetic Resonance Imaging (MRI);

c) Colour Duplex Sonography (CDS) of the carotid and vertebral arteries;

d) Transcranial Colour Duplex Sonography (TCDS), and

e) in selected cases, transthoracic echocardiography (TTE), and/or Magnetic Resonance Angiography (MRA).

MRI of the brain was achieved with a MRI unit (General Electric Medical System-Signa Horizon Lx 1.0 T, software LX versio 9.0). The standardized MRI protocol consisted of axial T_2-weighted images with fluid attenuated inversion recovery (Flair), coronal T_2-weighted images and sagittal T_1-weighted images. The vascular distributions of the infarcts were determinated with templates of cerebrovascular territories. The measurement of stenosis on MRA was computed directly on the maximum intensity projection and collapsed views. Results that were >50% were considered to constitue significant stenosis.

CDS of the carotid and vertebral arteries and TCDS were performed with MyLab 50 (E Saote). The degree of ICA and/or MCA stenosis were established by hemodynamic criterias (peak systolic velocity curbs; end diastolic velocity-curbs, etc.), and by the reduction, in diameter and surface, of the ICA lumen.

Statistical analysis

All results were expressed as mean +/- standard deviation (SD).

RESULTS

1) Table II indicates the characteristics of aphasics at admission.

Table 2. *Characteristics of aphasics at admission*

Patients (pts)	N=166
Gender, F/M	63/103
Age, years (mean+/- SD)	61.06+/-8.79
Interval time from stroke onset to hospitalization, h (mean +/-SD)	8.1+/-1.4

2) The clinical varieties of aphasia at admission are presented in fig 1.

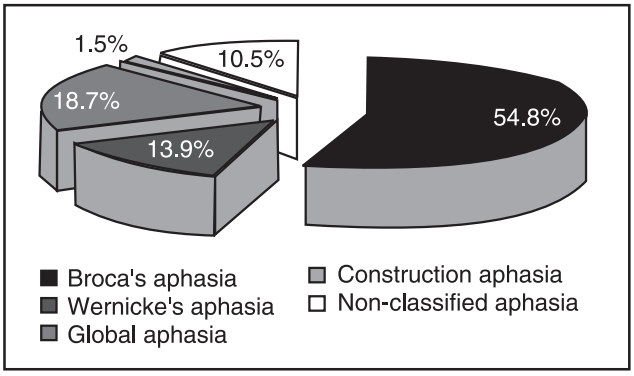

Figure 1. *The clinical varieties of aphasia at admission*

Between the 166 aphasics, 91 pts (54.8%) were with Broca's aphasia, 23 pts (13.9%), with Wernicke's aphasia, 31 pts (18.7%) with global aphasia, 3 pts (1.8%) with conduction aphasia, and 18 pts (10.8%) with non-classified aphasias.

3) Severity of aphasia at admission

The mean scores and the standard deviations (SD) for 4 subtests of the WAB (SS, C, R, and N) are indicated in table III.

4) Aphasia and cerebral infarcts (imaging – CT and MRI data):

- Among all 166 aphasics, in 125 cases (75.3%) the lesions were located at classical language centers, such as: Broca's area, Wernicke's area, arcuate fasciculus/and angular gyrus, etc.
- In 41 cases (24.7%) the lesions were located at other sites, besides language functional areas.

5) Transcranial Color Duplex Sonography (TCDS) and Color Duplex Sonography (CDS) results:

Between the 166 pts with aphasia and first acute ischaemic stroke, the TCD findings were:

A) 65 pts (39.1%) with no changes in the intracranial hemodynamics;

B) 101 pts (60.9%) with the following changes (fig. 2):

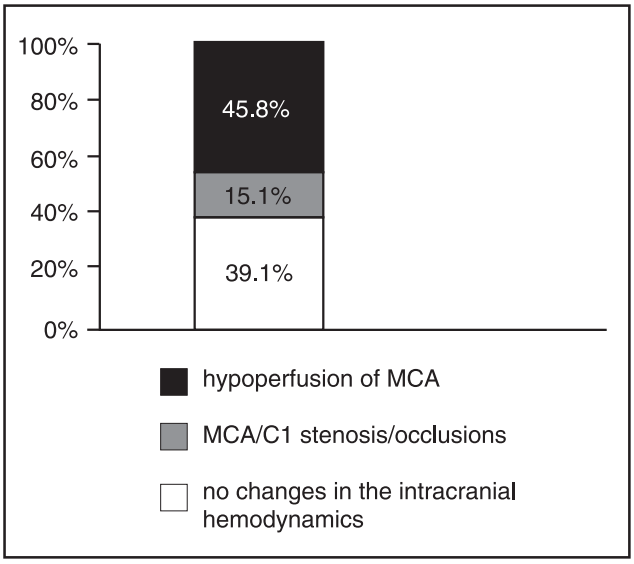

Figure 2. *TCD results in pts with aphasia and a first acute ischaemic stroke in the territory of the L or R MCA*

1) 25 pts (15.1%) with MCA or terminal ICA (C_1) stenosis/occlusions:

a) 11 pts (6.7%) with occlusion of the LMCA or LC_1;

b) 3 pts (1.8%) with no blood flow in the RMCA or RC_1;

c) 8 pts (4.8%) with significant stenosis of the LMCA or LC_1 (fig. 3, fig. 4);

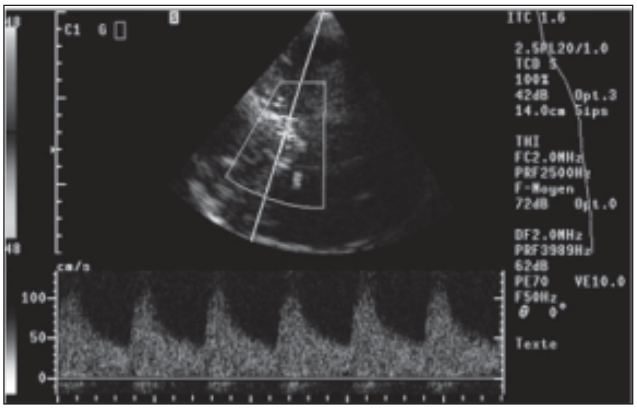

Figure 3. *TCDS transtem poral approach, axial midbrain plane, color mode (left C_1 stenosis – primary signs)*

Table 3. *Severity of aphasia at addmision*

WAB's subtest	Mean score	SD
Spontaneous speech (SS)	3.16	1.75
Comprehension (C)	5.4	1.91
Repetition (R)	4.77	1.72
Naming (N)	5.04	2.06

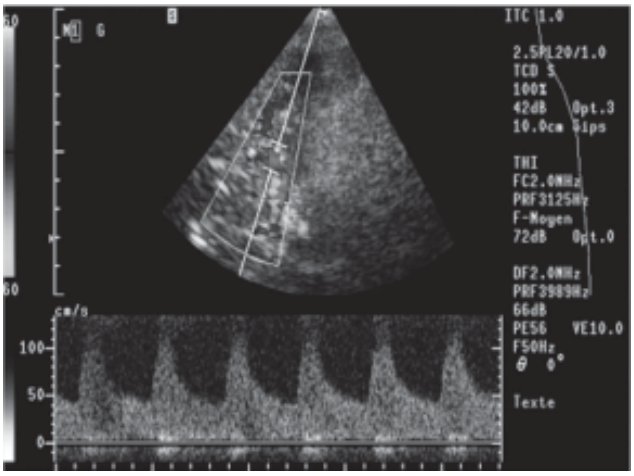

Figure 4. *TCDS, transtem poral approach, axial midbrain, plane color mode (left M1 higher grade stenosis – primary signs)*

d) 3 pts (1.8%) with significant stenosis of the RMCA or RC_1

2) 76 pts (45.8%) with hypoperfusion of the L and/or RMCA:

a) 45 pts (27.2%) with hypoperfusion of the LMCA;
b) 12 pts (7.2%) with hypoperfusion of the RMCA;
c) 19 pts (11.4%) with bilateral hypoperfusion of MCA.

Between the 76 pts with hypoperfusion of the L and/or R MCA, 34 aphasics (20.5% from 166 pts) had a significant stenosis (50-99%) or occlusion of the extracranial proximal ICA:

a) 20 pts (12.1%) had a significant stenosis of the L ICA;
b) 8 pts (4.8%) with no blood flow in the L ICA;
c) 5 pts (3%) had a significant stenosis of the R ICA (fig. 5);
d) 1 pt (0.6%) with an occlusion of the R ICA.

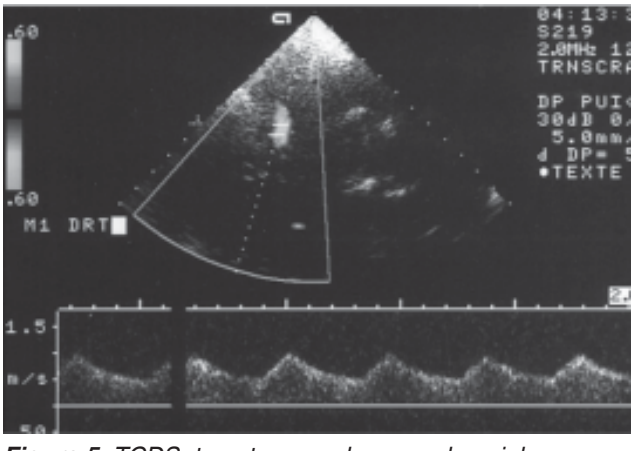

Figure 5. *TCDS, transtem poral approach, axial midbrain, plane color mode (lright proximal ICA occlusion, with right M_1 - MCA postestenotic flow pattern)*

Between the 34 pts with a significant stenosis/ or occlusion of the extracranial ICA, we evaluated the quality of intracranial collateralization (their hemodynamic risk) as following:

a) 17 pts (10.2%) were with anterior collateral circulation (through the anterior communicating artery-ACoA);
b) 3 pts (1.8%) were with posterior collateral circulation (through the posterior communicating artery-ACoP);
c) 2 pts (1.2%) were with both collateral circulations (ACoA, ACoP);
d) 1 pt (0.6%) was with leptomeningeal anastomosis (with increased velocities in proximal and distal segments of the posterior cerebral artery – PCA – and with retrograde flow signals in distal MCA branches);
e) 11 pts (6.6%) had a collateral pathways from ipsilateral external carotid artery (ECA), and ipsilateral ophthalmic artery (OA) (retrograde flow in the ipsilateral OA) (fig. 6).

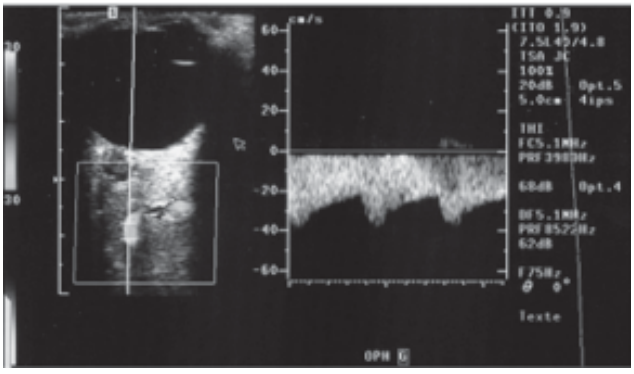

Figure 5. *TCDS, transorbitar approach (left proximal ICA occlusion with reverse direction of flox in the ipsilateral OA)*

DISCUSSIONS

The distribution of aphasic types in an acute aphasic population differs significantly from a chronic population (which has a higher number of Wernicke's and transcortical aphasics). Few studies have indicated the different types of aphasia expected in a setting of acute stroke. (10-13) In a survey of 850 pts with acute ischaemic stroke, Brust and associates (10) found that 177 pts (21%) had acute aphasia: 75 pts (32% of aphasics) had fluent aphasia and 120 pts (68%) nonfluent aphasia. Pedersen and associates (12) reported in a survey of 881 acute stroke, 38% aphasics (90% left MCA, 10% right MCA), with more than 50% severe aphasia (global aphasia).

In our study, more than half of total aphasics (91 pts out of 166) were with Broca's aphasia, and 31 pts (18,7%) with global aphasia.

The cerebrum irrigated by the left MCA is of prime importance in language function. Many of the traditional clinico-pathologic correlations of brain and language functions have undergone revisions in the last few decades under the influence of modern imaging. Among them, has been than much larger lesions are necessary to produce the lasting major disruptions in language function. Nevertheless, the lesion location is still the main determinant of the language syndrome (the occlusion of the trunk of the MCA or its upper division produces global aphasia). (16-19)

Cerebral angiography shows acute occlusion in 76% of acute MCA territory, infarcts within 6 h of stroke onset. (23) Follow-up studies show spontaneous recanalisation in the majority of cases by the end of 48 h and in up to 86% by 2 weeks. (24)

Transcranial Doppler (TCD) can detect these angiographic occlusions with high sensitivity and specificity, and has a high positive predictive value. (25) For this reasons, our pts underwent TCD in the first 24 h from admission.

TCD is also useful in prognostication of stroke:

a) a normal TCD at 6 h postischaemic stroke is an independent predictor of early improvement; (26)
b) in acute MCA stroke, blood flow velocity on TCD of <30 cm/s, within 12 h after stroke correlated with poor recovery. (27)

TCD diagnoses are based on the detection of altered blood flow velocity, absence of blood flow, changes in the color and in the spectral wave form, and changes in pulsatility in a specific intracranian arterial vessel.

Unfortunately, TCD may present inaccuracy, due to poor acoustic window (in up to 5-20%); for this reason we selected only pts with bilateral presence of temporal windows at TCD examination.

In our study, we used TCD in:

a) detection of site/degree of stenosis/occlusion of intracranial vasculature;
b) assessement of collateral flow in intracranial vasculature in cases of significant extracranial carotid artery stenosis or occlusion.

A) Use of TCD in evaluating the intracranial steno/occlusive arterial diseases:

Intracranial atherosclerosis is responsible for up to 10% of TIA and ischaemic strokes (28); in our study, 15.1% of pts were with MCA or C_1 stenosis/occlusions. Sensitivity, specificity, and positive and negative predictive values of TCD are generally higher in detecting abnormalities of the anterior circulation, than in the vertebro-basilar circulation, as the latter has more anatomical variations and can be difficult to localize for TCD insonation. (25) TCD can identifie higher grades of stenosis and occlusion fairly accurately: MCA stenosis has been most widely studied and can be diagnosed with a sensitivity of 86% and a specificity of 99%. (24) However, its role in diagnosing milder grades of stenoses is still uncertain; stenoses-like wave forms also occur in other conditions, like arterial spasm (as in subarachnoid haemorrhage), or due to increased collateral flow through hypoplastic communicators (ACoA or ACoP).

1) Primary signs of higher grades of MCA stenoses: (29)

a) for M_1 stenosis or C_1 stenosis:
- focal increase in mean flow velocity (=80 cm/s) at the site of luminal narrowing (>50% reduction in lumen diameter);
- focal increase in peak systolic velocity (PSV) =200 cm/s at the site of luminal narrowing (=50% reduction in lumen diameter);
- a velocity difference of =30% compared to the control site;
- spectral analysis confirms the presence of increased velocities, filling of the spectral window, and presence of turbulent flow during systole and diastole (suggesting high grade stenosis); lowering of signal intensity because of compromised blood flow due to narrowing;
- at color Doppler, presence of aliasing (due to increased velocities and turbulent flow).

b) for distal MCA stenosis:
- abnormal spectral tracing with increased velocities, filing of the spectral window and increased turbulence during systole;
- distal MCA stenosis can be missed with TCD, as the distal branches are not well visualized.

2) Secondary signs of stenosis: (29)
- decreased velocity and increased pulsatility upstream from the lesion;
- abnormal flow immediately down-stream from the lesion.

3) Signs of occlusion of MCA:

Intracranial arterial occlusions have been diagnosed using TCD with even greater accuracy and Demchuk et al have noted detailed diagnostic criteria for occlusion of large arteries. (30)

In general, the criteria for diagnosing an occluded intracranian artery based on TCD include:
- absence of signal from the artery, with an adequate temporal window, with visualization of the A_1 and P_1 segments;
- sonographic evidence of collateral flow.

In general, TCD has a high specificity, through sensitivity of TCD is lower in detecting and

quantification of intracranial stenosis and occlusions. (31)

B) Use of TCD in evaluation of extracranial ICA significant stenosis/occlusion, with assessement of intracranial collateralization.

Extracranial ICA disease is a significant cause of neurologic deficits, ranging from TIA's to progressive ischaemic stroke. The embolic risk rises as the degree of stenoses increases and in function of the echostructure of atheromatous carotid plaque. CDS is a sensitive and specific technique for demonstrating the presence and degree of narrowing of the proximal ICA. (32) TCDS is a useful adjuvant to this investigation in evaluating its haemodynamic consequences on the intracranial circulation (haemodynamic risk). In pts with haemodynamically significant extracranial ICA disease, TCD demonstrates:

1) a decrease in mean flow velocity, with diminished pulsatility (PI ↓) and diminished flow acceleration in the ipsilateral MCA;
2) normal flow in the controlateral MCA;
3) increased blood flow in potential collateral routes of circulation, tipically the controlateral ACA, PCA, ACoA and PCoA;
4) reversed direction of flow in the ipsilateral ACA, or PCA, or OA. (33,34)

CONCLUSIONS

1. In our study, Broca's aphasia was the most frequent aphasic syndrome in acute stage of ischaemic stroke.
2. The damaged lesions of most aphasics were melted with classical language functional areas, but other sites damaged also could produce aphasia.
3. TCD was an important non-invasive method for evaluation of the intracranial cerebral vascular diseases and of the intracranial hemodynamic impairement in the extracranial carotid diseases causing poststroke aphasia.

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