Transcranial Doppler Ultrasound in the Rehabilitation of Post-Stroke Patients

İnme Sonrası Hastaların Rehabilitasyonunda Transkraniyal Doppler Ultrasonografi

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Summary

Transcranial Doppler Ultrasound (TCD) is a noninvasive, inexpensive and portable imaging modality, which obtains information about the blood flow velocity in large intracranial arteries. TCD has several advantages in the investigation and treatment of acute ischemic stroke, but is inappropriately used in rehabilitation.

Normal blood flow velocity in the middle cerebral artery (MCA) of the damaged hemisphere after stroke is associated with better rehabilitation outcome. Improved blood supply to the damaged hemisphere is associated with a favorable outcome, oppositely to the undamaged hemisphere.

The decreased blood flow velocity in the damaged MCA is associated with orthostatic hypotension symptoms after stroke. Those patients are in high risk for developing syncopal reactions and should be elevated from supine position and treated on tilt table with caution, especially at the beginning of the rehabilitation.

The performance of speech tasks is associated in aphasia stroke patients with much lower left hemisphere activation in comparison with the healthy subjects. High blood flow velocity in the right MCA was found to be a good prognostic sign for language ability. Arterial blood flow shift towards the left hemisphere during speech tasks is associated with poor language ability.

The TCD technology can be an important additional tool for monitoring rehabilitation process, predicting functional outcome, evaluating brain reorganization strategies and developing new therapeutic modalities in post-stroke rehabilitation. *Turk J Phys Med Rehab 2005;51(2):42-44*

Key Words: Transcranial doppler ultrasound, ischemic stroke, rehabilitation, functional outcome

Özet

Transkraniyal Doppler Ultrason (TKD) invaziv olmayan, ucuz ve taşınabilir bir görüntüleme modalitesi olup geniş çaplı intrakranial arterlerin kan akım hızını gösterir. TKD'nin iskemik inmelerin araştırılma ve tedavilerinde birçok avantajı vardır, ancak rehabilitasyonda kullanımı yetersizdir.

İnme sonrası hasarlı hemisferde orta serebral arter (OSA) kan akım hızının normal olması rehabilitasyon sonuçlarını olumlu etkilemektedir. Hasarsız hemisferin aksine hasarlı hemisferde kan akımının artırılması olumlu sonuçlara yol açar.

İnme sonrası hasarlı OSA'da kan akım hızının azalması ortostatik hipotansiyon semptomları ile sonuçlanır. Bu hastalar senkop reaksiyonları açısından yüksek risk altındadırlar ve özellikle rehabilitasyon programının başlarında supin pozisyonundan kaldırılıp tilt masasında tedavi edilirlerken dikkatli olunmalıdır.

Normal sağlıklı bireylerle mukayese edildiğinde afazik inmeli hastalarda konuşma görevlerinin yapılması daha az sol hemisfer aktivasyonu ile birliktedir. Sağ OSA'da yüksek kan akım hızının, dil yeteneği açısından iyi bir prognostik faktör olduğu bulunmuştur. Konuşma görevleri esnasında arteriel kan akımının sol hemisfere kayması dil yeteneğinin yetersizliği ile birliktedir.

TKD teknolojisi, inme sonrası rehabilitasyon programının monitorizasyonu, fonksiyonel prognozun belirlenmesi, beynin reorganizasyon stratejilerinin değerlendirilmesi ve yeni terapötik modalitelerin geliştirilmesinde önemli bir ilave yöntem olabilir. *Türk Fiz Tıp Rehab Derg 2005;51(2):42-44*

Anahtar Kelimeler: Transkraniyal doppler ultrasonografi, iskemik inme, rehabilitasyon, fonksiyonel sondurum

Doppler is a noninvasive, inexpensive and portable imaging modality that uses sound waves directed toward a target blood vessel and the measurement of the Doppler shift of the reflected wave. From this, flow velocity is calculated. Aaslid et al. (1) demonstrated routine Transcranial Doppler ultrasound (TCD) examination of the intracranial arteries to be possible in 1982. TCD can show potency of any large intracranial artery throw one of "windows" upon the skull. TCD is the ideal rapid, real-time bedside tool for evaluation of cerebral vessels (2,3). It has several advantages in the rapid investigation and treatment of acute ischemic stroke particularly in the

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setting of thrombolysis (4,5). TCD is especially useful in the Middle Cerebral Artery (MCA) blood flow velocity measurements, where it reaches close to 100% specificity values (6,7).

It was shown before, that most significant changes in flow velocities according to TCD measurements take place in the first hours after stroke (8), but intracranial circulation can also be dynamic after weeks and months (9,10).

Several studies have shown that TCD findings can predict clinical outcome (11,12). Patients with acutely normal TCD have a favorable prognosis (13) and documented intracranial occlusion or a hemispheric asymmetry pattern is associated with a poor outcome (14). The persistence of occlusion appears particularly important.

In our recent study (15) we explored the association between Mean Flow Velocity (MFV) in the MCA of both hemispheres and the severity of functional disability and neurological impairment during in-hospital acute rehabilitation treatment of patients after a first-ever ischemic stroke in the MCA territory. Our findings suggest that TCD measurements on admission to the rehabilitation department are associated with Functional Independence Measure (FIM) and National Institutes of Health Stroke Scale (NIHSS) scores at the beginning and during the rehabilitation of ischemic stroke patients. As in the acute stage, absent or low MFV in the MCA of damaged hemisphere is correlated with a far worse functional and neurological outcome, especially after one and two months of inpatient rehabilitation. We found that higher MFV in MCA of damaged hemisphere is correlated with better functional and neurological parameters during two months of rehabilitation. This suggests that better blood supply to damaged hemisphere at the beginning of the rehabilitation period is associated with a favorable outcome. MFV in the MCA of undamaged hemisphere one month after admission was found to be in negative correlation with FIM values on admission, one and two months later. This suggests that better blood supply to the undamaged hemisphere during rehabilitation is associated with a poorer functional outcome. According to our study the repetitive TCD examinations are useful in predicting outcome in acute stroke patients.

TCD was found to be especially helpful in monitoring of blood velocities in large intracerebral arteries during postural changes (16). Orthostatic hypotension (OH) is a prevalent condition, which can lead to peripheral blood pressure drop in association with presyncopal symptoms or even vasovagal syncope, which is associated with ischemic stroke and can affect the rehabilitation outcome (17,18). Assumption of the upright position is associated with a reduction in venous return and cardiac output, and blood pressure is maintained with a sympathetically mediated increase in vascular resistance (19). Cerebral autoregulation refers to the inherent ability of cerebral blood vessels to keep cerebral blood flow constant over a wide range of systemic blood pressure (20). This ability is disturbed in stroke patients and can lead to a fall in cerebral blood flow velocity during orthostatic stress with head-up tilt (21).

Our recent study investigated the correlation between OH and MFV in the MCA bilaterally during Tilt Table Test (TTT) in acute ischemic stroke patients undergoing rehabilitation (Treger I, Shafir O, Keren O, Ring H, unpublished data, 2005). Our findings suggest that the appearance of OH symptoms is associated with decreased blood flow velocity in damaged MCA at the beginning of rehabilitation treatment after ischemic stroke. Among post-stroke patients the decrease in peripheral blood pressure during TTT is correlated with a drop in MFV in healthy MCA, but not in the artery in the damaged hemisphere. Patients with low MFV in the MCA of the damaged hemisphere, as measured by TCD, are in high risk for developing syncopal reactions and therefore should be identified on admission.

Changes in flow velocity in the large cerebral arteries are strictly related to changes in the diameter of small resistance vessels whose dilatation reflects an increase of regional metabolic activity and whose constriction reflects a decrease. Even if changes in blood flow velocities cannot be used for describing absolute values of cerebral blood flow, changes in flow velocity can be considered reliable indicators of flow changes and then of modification of brain perfusion in the territory supplied by the large intracerebral arteries (22). The possibility of investigating changes in cerebral activity during mental and motor activity with TCD has been widely validated in previous studies (23,24).

Studies of cerebral metabolism and blood flow have provided very interesting data about the importance of residual functionality of structures in the dominant hemisphere and of early activation of areas in the unaffected hemisphere in the recovery from aphasia and other neurological deficits (25). With TCD it is possible to obtain information about changes in cerebral activity in both normal and pathologic conditions (26).

High temporal resolution of TCD allows a continuous and bilateral monitoring of blood flow of the basal cerebral arteries. Functional TCD research examines velocity changes during the performance of mental tasks (27). These investigations are highly important for understanding of the normal brain functioning and the mechanisms of recovery after injury.

Our recent study investigated the correlation between the MFV in the MCA bilaterally during speech tasks in acute ischemic stroke patients undergoing rehabilitation (Treger I, Luzki L, Gil M, Ring H, unpublished data, 2005). Our findings suggest that the active functioning of the right hemisphere is extremely important in the improvement of language ability in post-stroke patients with aphasia during early stages of inpatient rehabilitation. The performance of speech tasks is associated in aphasia stroke patients with much lower left hemisphere activation in comparison with the healthy subjects, as detected by TCD monitoring. In our study, high blood flow velocity in the right MCA of aphasia patients was found to be a good prognostic sign for better language ability after one month of rehabilitation treatment. By comparison, a high MFV in the left hemisphere MCA was associated with worse speech recovery during the first month of hospitalization. A shift in arterial blood flow toward the left hemisphere during speech tasks was associated in our study with pure language ability one month after stroke. Our study shows the increased role of the right hemisphere in lexical-semantic processing by aphasia patients during early recovery in sub-acute in-patient rehabilitation. It can be important in developing new, effective techniques of post-stroke language rehabilitation.

The American Academy of Neurology technology assessment report (28) stated that TCD has established value in the assessment of patients with intracranial stenosis, collaterals, subarachnoid hemorrhage, and brain death. It is widely used in stroke units, neurology, neurosurgery, cardiology, vascular surgery, and other departments of acute patients' care.

So far, TCD technology is not appropriately used in the neurological rehabilitation departments and only some investigations were done to evaluate the significance of later changes in the brain hemodynamics after brain injury.

Early prediction of improvement is essential for planning the reintegration of patients into social life and their need for care and, more specifically, for selecting subjects who might benefit most from rehabilitation. The results of brain reorganization studies by the functional TCD can help a lot in developing new effective techniques in stroke patients' rehabilitation.

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