Brain parenchyma sonography

S. Sanguigni
C. Paci
T. Carboni
R. Gobbato
G. D'Andreamatteo
S. Sobrini
V. Urbano
A. Brandimarti
L. Curatola

Department of Neurology, "Madonna del Soccorso Hospital", San Benedetto del Tronto (AP), Italy
E-mail: ale.dani@libero.it

Transcranial sonography in adult patients is, without doubt, a challenging area because it raises a number of difficulties (ultrasound dampening caused by cranial bone, axial and lateral resolution of the ultrasound beam, progressive reduction of the resolution with decreasing transducer insonation frequencies, etc.). Although we recognise the scientific importance of these difficulties, linked exclusively to the physical limits of the ultrasound technique, the advent of last generation software imaging nevertheless encourages us to pursue the idea of a possible useful *sonographic* bi-dimensional approach to the *non-ischaemic pathologies* of the brain parenchyma. In general, our experience, as already quoted in several papers in the literature (1,2), shows that when a sufficient acoustic bone window is present, it is sometimes possible to detect the presence of brain expansive processes: tumours, subdural haematomas, brain haemorrhages (3-5). The ultrasound examination can, obviously, only arouse the suspicion of expansive pathologies, which must then be confirmed by neuroradiological examinations. Nevertheless, we must not ignore this *innovative* aspect of the TCCD method. Furthermore, in the follow up of patients undergoing surgery for subdural haematoma, TCCD will offer valid, non-invasive assistance in monitoring the more or less complete re-absorption of the haematoma and/or post-surgery subdural pneumo-encephalon.
In addition, TCCD allows us to detect indirect signs of space-occupying masses:
– third ventricle midline shift
– middle cerebral artery shift (for temporal space-occupying masses)
– posterior cerebral artery-shift (for hippocampal uncus space-occupying masses).
While the predictive value of midline shift alone is certainly far from immediate and really *very approximate*, it is nonetheless true that its association with the other two elements can give us useful information.
Measurement of the *third ventricle width* is certainly a valid clinical element which can supply us with useful indications both about the presence of possible *hydrocephalus* but, in particular, about the *efficiency* of a ventriculoperitoneal or ventricoloatrial shunt. Not only are these data are of great importance in the monitoring of intensive care unit therapy, they also enable us to detect, in a few minutes and with certainty, cerebral areas of different density and thus to *optimise* both the treatment of the patient and the rationalisation of the neuroradiological examinations (CT scan and MRI).
The literature contains several papers, most of them by the German school, concerning the study, with ultrasound, of *extrapyramidal pathologies*. We are seeing increasing confirmation of the possibility of detecting echogenicity of particular anatomical structures in the course of some CNS degenerative diseases, such as the presence of substantia nigra (SN) hypecogenicity as a **"subclinical marker"** idiopathic Parkinson's disease (IPD). Whether this echogenic pattern is to be related to the accumulation of iron and/or calcium at the level of the SN is debated. Recent surveys seem to exclude the involvement of calcium. On the other hand, genetic studies (6,7) showed, in patients with PD, mutations of several genes involved in iron metabolism in the brain. Mutation of the ceruloplasmin gene is often present in these patients. This picture is absent in healthy controls. Nevertheless, the literature evidence confirms that SN hyperechogenicity is present in IPD patients and not in patients with essential tremor. An SN larger than 0.20 cm^2 is indicative of pathology. In conclusion, with regard to the relationship between parkinsonism and SN hyperechogenicity, from the literature (8) we can infer that:

- In patients with normal SN echogenicity (< 0.20 cm^2) a diagnosis of multisystem atrophy is more likely
- In patients with normal SN echogenicity and a hyperechogenic lenticular nucleus, a diagnosis of IPD is more unlikely
- In patients with early onset of parkinsonism (< 60 years) showing normal SN echogenicity, a IPD is more unlikely
- In patients with a third ventricle width >10 mm and a hyperechogenic lenticular nucleus, a diagnosis of progressive supranuclear palsy is more likely.

Moreover, our Neurology Department has documented the presence of flowmetric variations between ON and OFF phases in IPD patients (9). Most typical features in advanced IPD patients are the ON-OFF phenomena: abrupt response swings not related to the timing of medication, with rapid progression of symptoms making speech and gait impossible.

Right and left middle cerebral arteries (MCA), in the MI segment, were studied. Peak systolic velocity (PSV) and peak end diastolic velocity (PEDV) were evaluated. Blood pressure and oxygen saturation were monitored. Statistical evaluations included Student's t test and the paired Wilcoxon test between ON and OFF stages. In both MCA we found statistically highly significant differences between ON and OFF blood flow. Our data suggested that in some stages of advanced PD the cerebral blood flow could show important changes that were independent of systemic blood pressure and oxygen saturation.

We also recall two other applications of brain sonography (TCCD):

- the finding of reduced echogenicity of the brainstem raphe, due to alteration of the serotoninergic fibres, is more frequent in patients with depressive disorders (10).
- A very recent use of TCCD is localisation of deep brain stimulation electrodes in patients with movement disorders (in particular in PD not responsive to drug therapy).

In conclusion, transcranial B-mode sonography has become an important tool for the diagnosis of some extrapyramidal diseases and for brain parenchyma sonography in general. Among other functional neuroimaging methods, ten years ago Postert (11) affirmed that: "The availability of PET and MRI scanners is limited, the running costs are high and performance of these methods is nearly impracticable in acute stroke patients. In contrast TCCD represents a rapid and easily applicable bedside examination". Currently, while MRI and PET undoubtedly remain the "gold-standard" methods for parenchyma study, TCCD is a very useful, inexpensive bedside neurological tool which, in our opinion, could be recommended for general application in routine examination of neurological patients.

References

1. Bartels E. Color-Coded-Duplex Ultrasonography of the Cerebral Vessels. Atlas and Manual. Stuttgart; Schattauer publisher 1999:201-204
2. Malferrari G, Sanguigni S, Accorsi F. Eco-color-doppler transcranico. Testo atlante (con DVD) Fidenza; Mattioli 1885 publishers 2006:149-185
3. De Campora P, Malferrari G, Sanguigni S, Sangiuolo R. Transcranial color-coded sonography for the detection and follow-up of space-occupying hemorrhagic strokes. Cerebrovasc Dis 2006;21(S-3):4
4. Sanguigni S, Dardari A et al. The use of TCCD to detect intracerebral masses (tumors and subdural hematomas). Cerebrovasc Dis 2004;17(S 4):1-36
5. Sanguigni S, Paci C, Carboni T, Gobbato R, Curatola L. A new application of parenchyma study with ultrasound: TCCD could play a role in detecting subdural hematomas. Neurol Sci 2007;28(S):325
6. Zecca L, Wilms H, Geick S et al. Human neuromelanin induces neuroinflammation and neurodegeneration in the rat substantia nigra: implications for Parkinson's disease. Acta Neuropathol 2008;116:47-55
7. Zecca L, Berg D, Arzberger T et al. In vivo detection of iron and neuromelanin by transcranial sonography: a new approach for early detection of substantia nigra damage. Mov Disord 2005;20:1278-1285
8. Berg D, Godau J, Walter U. Transcranial sonography in movement disorders. Lancet Neurol 2008;7:1044-1055
9. Walter U, Hoeppner J, Prudente-Morrissey L, Horowski S, Herpertz SC, Benecke R. Parkinson's disease-like midbrain sonography abnormalities are frequent in depressive disorders. Brain 2007;130:1799-1807
10. Curatola L, Sanguigni S, Malferrari G, Carboni T, Gobbato R, Paci C. Changes in cerebral blood flow detected in the middle cerebral arteries, in patients affected by idiopathic Parkinson's disease, during on-off phenomena. A transcranial color Doppler study. J Neurol 2002;249(S.1):1-224
11. Postert T, Federlein J, Weber S, Przuntek H, Buttner T. Second harmonic imaging in acute middle cerebral artery infarction. Preliminary results. Stroke 1999;30:1702-1706