Terrace of Medical Engineering Ultrasound

Transcranial Doppler, Present and Future

Leo Hoogendoorn, MSc.

Nicolet-EME GmbH

Since its introduction in the early eighties, TCD has established itself as a valuable non-invasive tool for assessing the bloodflow in the major arteries of the brain. As such, it is important to either help prevent, or, alternatively, to help assess the damage of Stroke. Today, the emphasis is slowly changing from a purely diagnostic tool to a (longer-term) monitoring tool, that helps protect the brain during and after procedures with increased risk to the patient's brain. The development of easy-to-use and reliable emboli detection will further this goal.

Key words: transcranial Doppler (TCD), emboli detection, educational software

Introduction

Since Rune Aaslid's first publication on Transcranial Doppler Sonography (TCD) in 1982, and his consequent cooperation with EME in launching the first commercial instrument in 1983 (TC2-64), a lot has happened. TCD is today an accepted clinical tool in many institutes around the world, and is further used in research in many areas. The fact that it is non-invasive, continuous, real-time, economic, provides direct "audio" feedback to the operator and last-but-not-least that no harmful effects have ever been observed, have all helped to accelerate its acceptance.

TCD Today

In the United States, the American Academy of Neurology (AAN) has formally recognized five indications for clinical TCD: Intra-Cranial Stenosis, Collateral Pathways, Cerebral Vasospasm, Arterial-Venous Malformations and Brain Death. Aside from these five areas, TCD is being applied in many more around the world, such as in Sickle Cell Anemia, Physiological Testing, Emboli Screening, Assessment of Patent Foramen Ovale, Pharmacological Follow-up, Positional Ischemia, Migraine, Sleep, Functional Testing and Venous Outflow. Most importantly though, TCD can be expected to become a standard tool in future Patient Monitoring, both in the Operating Theater and in the Intensive Care Unit.

Besides the advantages of TCD that were mentioned before, the technology also has some pitfalls: it requires a skilled operator, will have a percentage of cases where skulls can not be penetrated, and in the case of

monitoring, needs a reliable and adequate probe fixation. Finally, TCD measures velocity rather than (volume) flow, and thus diameter changes need to be taken into consideration by the reader.

Nowadays, Transcranial Duplex-Imaging (TCI) is often presented as an alternative to TCD by the manufacturers. Whereas this technology is certainly producing attractive pictures, it should be remembered that, because of the completely different physical properties of the transducers (wide band versus narrow band for example) it can not be expected to ever reach the sensitivity of a dedicated TCD system, and will thus only perform optimally in (mainly younger) patients with good acoustical windows. Because of probe size and cost considerations, such systems are also not suited for use in patient monitoring.

The introduction of reliable contrast enhancement agents may lower the failure rate of both TCI and TCD. Today, this enhancement will only last for a few minutes however, and thus not be beneficial to, even short-term, monitoring

TCD Future

At Nicolet-EME, we continue to work on the pitfalls of TCD: better probes and probe fixations, more automation in signal acquisition and analysis, and more sensitive systems, in order to decrease user dependence and increase overall ease of use. We are further combining the TCD data with other parameters, such as vital signs or Electro-Encephalography (EEG) and Evoked Potentials data, in order to get as complete a "picture" of brain function as possible.

One example of better analysis is the Advanced

Fig. 1 Small carotid embolus automatically detected and enhanced by the program in high-resolution spectrum. The normal flow is barely visible in the background.

Fig. 2 TCD Simulator showing complete circle of Willis, various Doppler approaches and choice of degrees of carotid stenosis or even occlusion.

Emboli Detection project, in close co-operation with one of the leaders in the field, Dr. Hugh Markus (London, UK). The goal of the project is to achieve a sensitivity and specificity of over 90 %, or as good as the agreement rate between trained human observers, for the so-called micro emboli originating from carotid plaque and atrial fibrillation. Right now, we seem to be nearing this goal, with a proprietary real-time algorithm that uses on-line digital filtering combined with multivariate analysis (Fig. 1). The final results will be published by Dr. Markus within the next few months, and the method is expected to eliminate subjectivity and operator dependence to a large extent.

Over the last 15 years, TCD has given us a better understanding of Cerebral Hemodynamics, and thus into the underlying causes of Stroke. A lot of this knowledge has been combined in a so-called TCD simulator package, designed by Dr. Rune Aaslid, and distributed by Nicolet-EME (Fig. 2). It allows the user to simulate a large number of pathological conditions in the brain, and thus become better acquainted with their effects on cerebral blood flow.

Conclusion

In conclusion, TCD is an important tool in Protecting the Brain today, and is expected to remain so in future.