Comparison of transcranial color Doppler imaging (TCDI) and transcranial Doppler (TCD) in children with sickle-cell anemia

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Abstract Background. Transcranial Doppler (TCD) has been demonstrated to identify those at highest risk of stroke among children with sickle-cell disease. Based on a randomized clinical trial [Stroke Prevention in Sickle-Cell Anemia Trial (STOP)], which ended in 1997, the National Heart Lung and Blood Division of NIH has recommended TCD screening and chronic blood transfusion based on Nicolet TC2000 dedicated Doppler (TCD). Studies performed using TCD imaging modalities need to be correlated to that used in the clinical trial to provide information for treatment decisions when screening with TCDI.

Objective. To correlate transcranial arterial time-averaged mean velocities obtained from an Acuson Transcranial Doppler Imaging to those obtained using the TCD as the gold standard for treatment decisions based on STOP.

Materials and methods. A total of 29 children with sickle-cell disease, age 3–16 years, were studied at one of two scanning sessions using both techniques and a scanning protocol based on that used in STOP performed and read independently. The average difference in the measured velocities for each arterial segment was tested to determine difference from zero. Differences were compared before and after modifications to the TCDI technique were made to mimic the STOP protocol more closely.

Results. TCDI velocities were generally lower than TCD velocities for the same segment, but the difference was reduced (from 15% to 10% for the middle cerebral artery) by modifications to the TCD protocol.

Conclusions. Measurements using the Acuson system are modestly lower than those obtained with dedicated Doppler using the Nicolet TCD.

Background and purpose

Ischemic stroke is a frequent and potentially devastating complication of homozygous sickle-cell anemia (HbSS). It occurs in 11% of patients with HbSS before the age of 20 [1, 2]. These strokes are primarily the result of stenosis or occlusion of the distal intracranial internal carotid arteries (ICA) and/or proximal middle cerebral arteries (MCA). These sites of stenosis are readily assessable by transcranial Doppler (TCD). A series of papers on TCD demonstrated that HbSS patients who have high velocity flow in the distal ICA and proximal MCA have a significantly increased risk of stroke [3–5]. The ability to select high-risk patients using TCD led to the first randomized, controlled clinical trial of stroke prevention in HbSS [6]. The Stroke Prevention in Sickle Cell Anemia Trial (STOP) confirmed that children with time-averaged mean of the maximum (TAMM) flow velocities of ≥200 cm/s in the distal ICA or proximal MCA have a stroke risk of about 10%/year that is
10–20 times that of children with HbSS of the same age [2]. The study demonstrated that this risk is reduced to < 1%/year by regular blood transfusions sufficient to reduce the HbS from about 90% (untreated) to < 30% of total hemoglobin [6].

STOP used dedicated Doppler (“blind” or non-imaging TCD) [7] to identify children for treatment. The TCD protocol was specifically adapted for use in children with sickle-cell anemia, emphasizing meticulous TCD scanning technique and signal optimization with documentation of the highest TAMD. As a result of the findings of this study, the NIH released a Clinical Alert (September 18, 1997), which stated “The STOP Trial confirms that TCD can identify children with sickle-cell anemia at high risk for first-time stroke. Since the greatest risk of stroke occurs in early childhood, it is recommended that children ages 2–16 receive TCD screening. Screening should be conducted at a site where clinicians have been trained to provide TCD of comparable quality and information content to that used in the STOP trial and read them in a manner consistent with what was done in STOP... It is recommended that centers that wish to start screening children with sickle-cell anemia for stroke risk do studies to compare their current equipment with STOP trial TCD equipment” [8]. This Clinical Alert identified a potential problem in the use of the TCD data from STOP; although TCD and TCDI both use the Doppler principle to determine the velocity of blood flow, there are differences in the way that data are acquired and processed that could result in differences in the measured velocity. Significant discrepancy can result in failure to identify children who need to be treated or treatment of children at relatively low risk, which may not be indicated. If the STOP results are to be widely utilized for identification and treatment of children at risk for stroke, the comparability of the two methods should be evaluated.

As a result of the STOP findings, the demand for TCD screening of children with HbSS has increased. While “blind” TCD is an affordable, reproducible technique that has been used since 1982, it is not available in all medical centers. Many centers without access to “blind” TCD do have access to color Doppler imaging systems (TCDI) [9]. The TCD technique has been previously described [10] and uses 2-MHz pulsed Doppler sonation through the temporal bone to identify flow velocities in the anterior and posterior portions of the circle of Willis (Figs. 1–3). In the absence of a B-mode image, the head diameter, sample volume depth, flow direction, vessel traceability, and probe position are used to identify the specific intracranial arteries and