Supplementary Table S1 TCD protocol for critically ill children

I. Indication and request for examination standards
   a. Review the patient’s history (age, gender, past medical history, signs/symptoms, previous TCD studies, or other relevant available neuroimaging).
   b. Review documentation of the treating team's specific question for TCD examination.

II. Technical performance standards
   a. Find a comfortable position that allows access to the patient and the equipment.
   b. Due to clinical requirements, critically ill children can often not be positioned in a standard, recommended fashion. Perform the examination in any position necessary as long as the results appear technically adequate.
   c. Examine the intracranial arteries via four ultrasound windows (transtemporal, transorbital, submandibular, and transforaminal).
      i. Use the transtemporal window to evaluate the MCAs, ACAs, PCAs, and the ICAs.
      ii. Use the transorbital window to evaluate the OA.
      iii. Use the submandibular window to evaluate the Ex-ICA and distal ICA.
      iv. Use the transforaminal window to evaluate the VAs and BA.
   d. Perform a complete TCD examination by evaluating the following vessels bilaterally: MCA, ACA, PCA, ICA, Ex-ICA, VA, and the BA unilaterally. Complete examinations should be performed in most cases in order to understand any important cerebrovascular changes.
      i. Perform a limited examination on any one or more vessel(s) only if a specific clinical question is being evaluated.
   e. A zero-degree angle of insonation is assumed during the TCD examination.
   f. Identify the vessel being evaluated by confirming the direction of flow, flow
velocities, and the depths of insonation.

g. In the transtemporal window, it is not necessary to measure the head to determine midline. Use the MCA/ACA bifurcation (sonographically located) as a landmark for identification of the midline. Vessels can then be insonated as the probe angle is altered and depth is advanced or reduced.

h. At each depth setting, employ “signal optimization” so that the best quality Doppler signal possible (one with the sharpest waveform and the highest velocity signal at each depth) will be obtained.
   
i. Signal optimization is accomplished by proper instrument settings which are preprogrammed but can be adjusted.
   
   ii. Minor manipulations of transducer positioning are operator dependent and are often required.

i. Evaluate each intracranial artery along its entire length, every 2 mm.
   
i. The MCA should be evaluated from 65 to 35 mm in adolescents.
      1. In younger patients, this is less deep due to smaller head size.

   ii. The OA should be evaluated from 40 to 50 mm in adolescents.
      1. In younger patients, this is less deep due to smaller head size.

   iii. The Ex-ICA and distal ICA should be evaluated from 40 to 60 mm in adolescents.
      1. In younger patients, this is less deep due to smaller head size.

   iv. The BA should be evaluated from 65 to 80 mm in adolescents.
      1. In younger patients, this is less deep due to smaller head size.

j. Digitally label, save, and record all spectral waveform profiles.

III. Interpretation standards

   a. Consider key physiological variables (temperature, mean arterial pressure, carbon dioxide, hemoglobin or hematocrit, intracranial pressure, cerebral
perfusion pressure) at the time of TCD examination.

b. Consider if treatments known to impact measured TCD flow velocities such as the presence of invasive or noninvasive mechanical ventilation and/or the use of sedatives or anxiolytics being used in the care of the child being evaluated.

c. In children, intracranial arterial cerebral blood flow velocities vary by age. Compare cerebral blood flow velocities captured in children in the PICU to normative values in healthy children as reported by Bode and Wais.²
d. Consider a measured flow velocity to be abnormal when ≥ or ≤2 standard deviations from the age normal value.
   i. Measured flow velocities ≥2 standard deviations likely represent either hyperemia or cerebral vasospasm but no ratios have been validated in children to differentiate between the two in either the anterior or posterior circulation.

e. Compare Doppler spectral waveforms from the anterior and posterior circulation, and from the right and left sides.
   i. The difference in mean velocity between sides is normally less than 30% with differences greater than this suggesting pathology.

f. Evaluate the Doppler spectral waveform configuration and note abnormalities such as delayed upstroke, reversal of flow, or embolic signals that suggest pathology.

IV. Data reporting standards

a. Discuss the preliminary report as soon as feasible with the referring physician. Complete a final, official interpretation of the TCD study within 24 hours.

b. Document in the medical record:
   i. The initials of the operator.
   ii. The clinical indication for the examination.
   iii. The following technical parameters: imaging vs. nonimaging device, head of the bed position, vessel segment and side (right or left), sample volume, gain, and power settings.
iv. The technical adequacy of the examination.

v. If the examination is complete or limited.
   1. If limited, an explanation for why only a limited examination was performed.

vi. The range of depths flow velocities was measured in each vessel.

vii. The average systolic, diastolic, mean flow velocity, and pulsatility index (PI) for each vessel.

viii. The number of standard deviations of measured cerebral blood flow velocities from normal reference values for each evaluated vessel should be reported.

ix. Consider including representative Doppler spectral waveforms for each insonated vessel.

Abbreviations: ACA, anterior cerebral artery; BA, basilar artery; ICA, internal carotid artery; MCA, middle cerebral artery; OA, ophthalmic artery; PCA, posterior cerebral artery; TCD, transcranial Doppler ultrasonography; VA, vertebral artery.