



**Transcranial Doppler Scanning for
Children with Sickle Cell Disease
Standards and Guidance
*Third Edition February 2026***

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Introduction

The following standards have been written to replace the second edition Transcranial Doppler (TCD) standards published in September 2019. These updated standards include clarification of the target age group, new guidance for non-imaging and imaging TCD non-diagnostic findings and provide information on training, quality assurance, the National Haemoglobinopathy Registry and the TCD Practitioner Register held by the UK Forum.

List of main contributors

Many people have contributed to these standards and guidelines, and we would like to thank them all for their input. Major contributions have been made by, Dr Soundrie Padayachee, Dr Colin Deane, Dr David Goss, Professor Baba Inusa, Dr Paul Telfer, Dr Banu Kaya, Joanne Walker, Dr Vivian Tang and Dr Sara Mazzucco.

Organisation of TCD scanning services

All children and young adults with sickle cell anaemia (Hb SS) and HbS β zero thalassaemia, should be offered annual TCD scans from age 2 years until age 16 years. The need for children with other types of sickle cell disease to be screened should be reviewed on a case-by-case basis.

TCD or TCD imaging (TCDi) are both acceptable techniques for performing screening, with the method of choice depending on local circumstances but all scans must be performed by competent TCD practitioners.

It is expected that the mode of delivery of the service and choice of equipment will depend on the local configuration of clinical services for children with sickle cell disease. This will probably be determined by the prevalence of the condition in any area. Children could be scanned in an outpatient clinic environment, ultrasound department or in the home. There should be a lead TCD specialist/clinician taking responsibility for directing the TCD scanning services within their locality, ensuring that documentation of procedures, risk assessments and safeguarding are in place.

All parents and carers should be given a verbal explanation of the TCD scanning process and limitations of the procedure, together with an explanation of the follow up process if an abnormality is found. The association between high blood velocity in the cerebral arteries and the risk of a stroke should be made clear and hence the purpose of the test. Sufficient verbal and written information (see Appendix) should be given to enable an informed decision to be made about the necessity of the TCD scan and accepting the consequences of chronic transfusion if an abnormality is detected.

Scanning protocols and follow-up

The protocols for TCD scanning and categorisation are based on the criteria developed from the first Stroke Prevention Trial in Sickle Cell Anaemia (STOP 1 trial) in the United States; this trial used non-imaging TCD. Non-imaging TCD and imaging TCD (TCDi) using duplex scanners, are both

effective methods to examine children with SCD. There is sufficient evidence that, with correct technique, optimisation and measurement, the same velocity thresholds can be applied for both methods. It is recommended that the method of scanning (TCD or TCDi) should be quoted on the report.

Operators undertaking scans must demonstrate proficiency to scan, which will be determined by attendance at a recognised training programme and successful competency evaluation. Competent TCD operators will be eligible to apply for inclusion in the UK TCD Practitioner’s Register held by the UK Forum.

Arterial blood velocities must be examined in the distal intracranial internal carotid artery (dICA), middle cerebral artery (MCA) and anterior cerebral artery (ACA) on both sides of the head. Posterior cerebral artery (PCA) values may be recorded optionally.

TCD scan decision making Algorithm 1, summarises the STOP stroke risk classification, which should be based on the highest time averaged maximum mean velocity (TAMMV) measured in either the distal ICA (dICA) or MCA or ACA with TAMMV cut-offs as identified in the STOP trial. The action taken following the categorisation of results should follow the protocols as given in the associated algorithms. Repeat TCD scans should be undertaken at the time intervals recommended. There is no RTC evidence to support reducing scan intervals in children with high conditional velocities or in younger children. However, lower levels of evidence (guideline panels and observational studies) have reported increased conversion to high risk, supporting closer TCD monitoring. Decisions to adjust intervals should be based on Clinician review, considering factors like age and prior TCD results.

Normal velocity - low risk	All velocities < 170 cm/s
Borderline velocity – conditional risk	Any velocity in the range 170-199 cm/s
Abnormally high velocity – high risk	Any velocity in the dICA/MCA/ACA \geq 200 cm/s

The original STOP study did not include a category for abnormal velocities in the ACA. Subsequent analyses indicate a raised risk of stroke in cases of ACA velocities \geq 170 cm/s. These findings should prompt early repeat scanning with further clinical and imaging investigation for possible intervention. ACA velocities \geq 200 cm/s should be considered as high risk.

Low velocities or pronounced asymmetry in the MCA are indicative of possible occlusion and should prompt further investigations and alternative imaging.

Unusual low velocities	Velocities <70cm/s in MCA
Asymmetrical velocities	Velocity <50% of contralateral MCA
Non-diagnostic and Incomplete imaging	Incomplete TCD scan measurements from dICA, MCA or ACA bilaterally

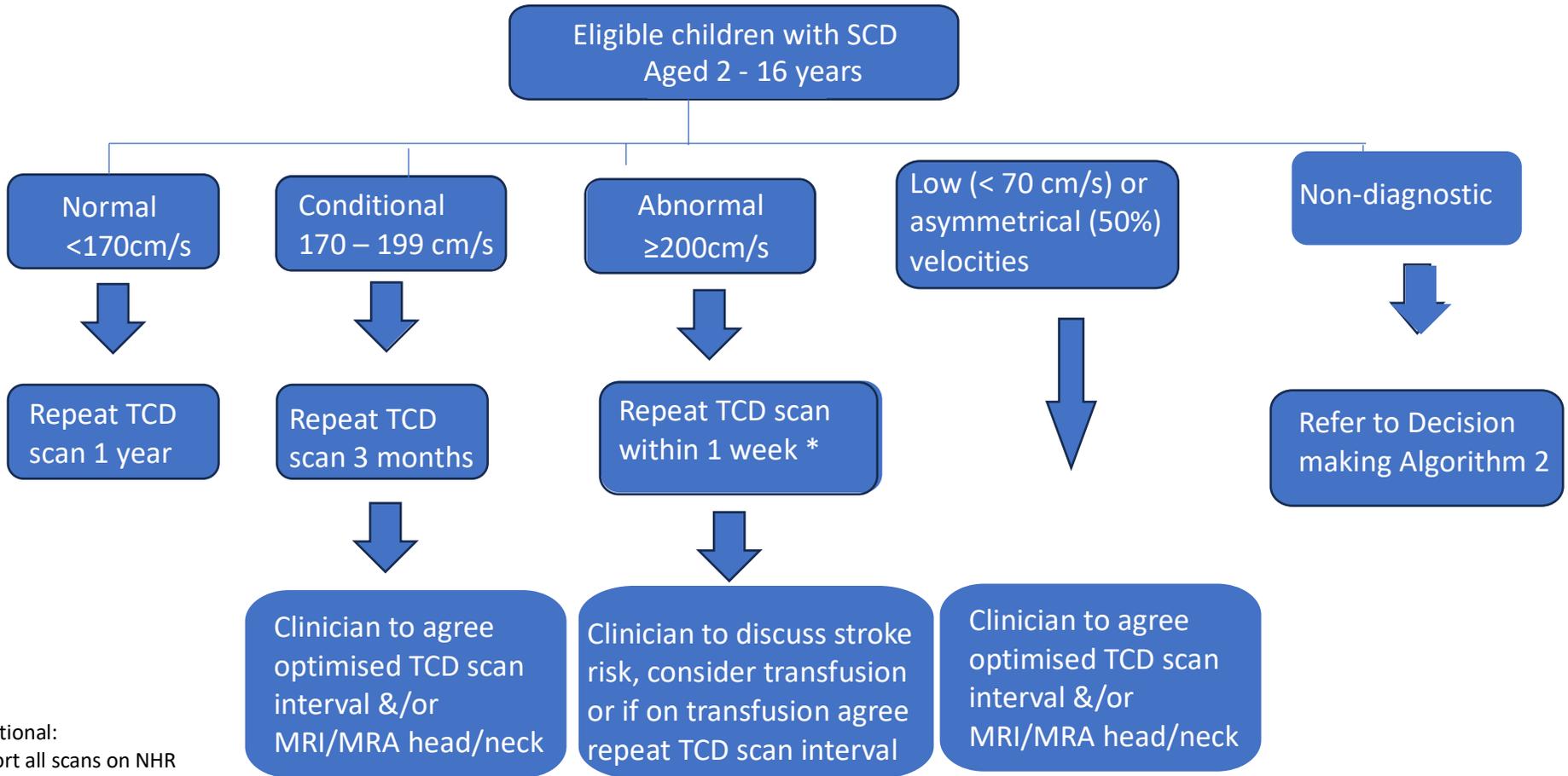
TCD Algorithm 2 provides guidance after repeated, failed TCD scanning. This might be due to an

uncooperative child; in which case a repeat scan should be considered within 3 months. A TCD scan is defined as non-diagnostic if after two attempts, no velocities are obtained and as incomplete if TCD velocities are not recorded from all 6 vessels. Options are to perform a repeat scan by a local TCD expert, use of an alternative TCD modality (imaging or non-imaging) or referral for MRA/MRI.

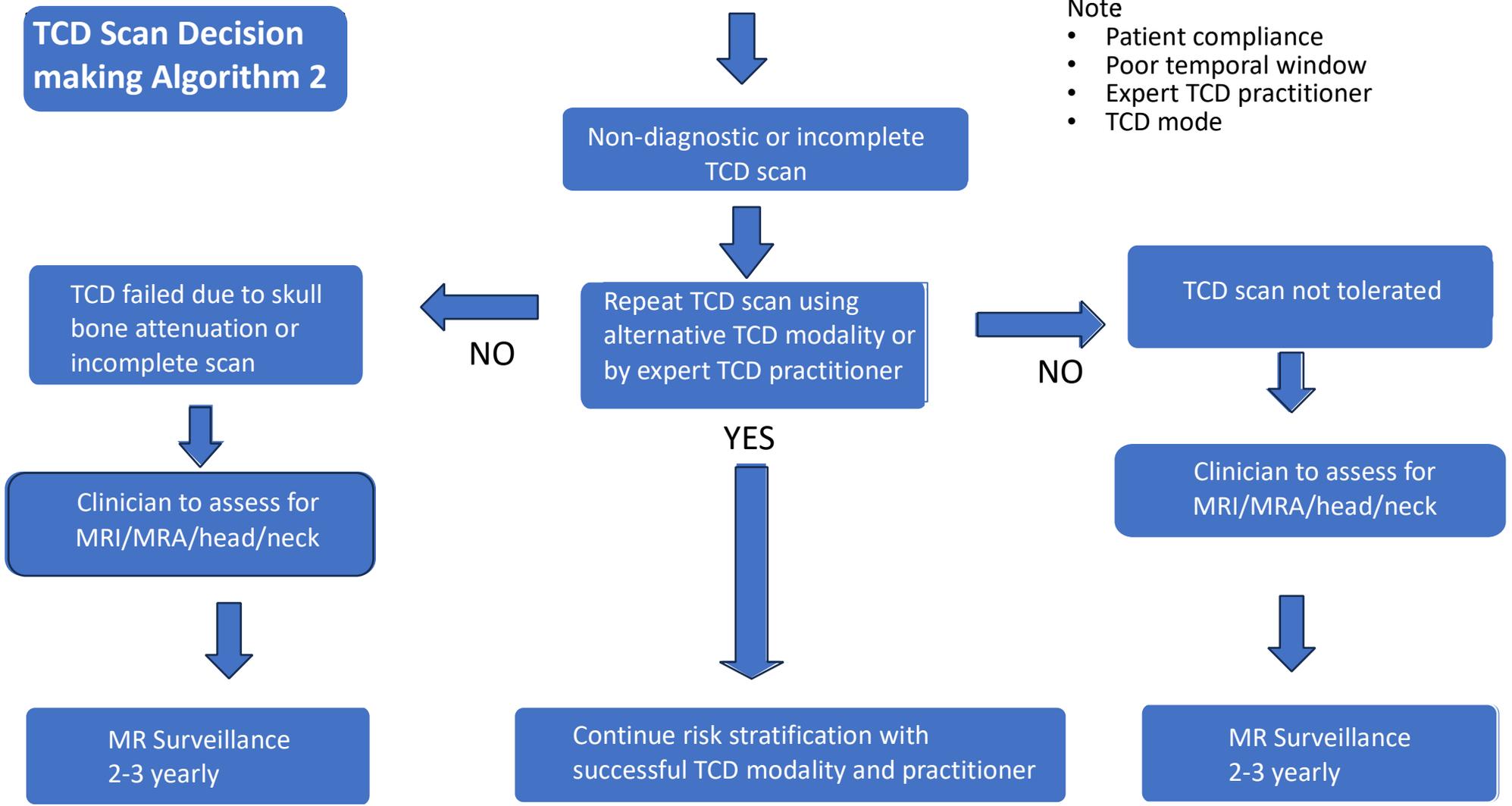
Because of the long-term consequences of starting chronic transfusions in children at high risk, all available data should be considered prior to beginning treatment. Repeat TCD scanning is recommended for all abnormal classifications. The assessment should also include a comprehensive neurological assessment and the results of other imaging studies such as MRI/MRA, although these are not used in the risk classification and treatment should not be altered or delayed for this reason.

Ongoing TCD scanning is recommended once a child has started on regular transfusions. Raised velocities may return to normal levels with transfusion, and if this fails to happen or if velocities increase, further investigations and interventions should be considered. The time interval for performing these scans should be yearly or shorter depending on the TCD velocity and the individual clinical circumstances.

TCD Scan Decision making Algorithm 1



TCD Scan Decision making Algorithm 2



Extracranial internal carotid artery examination

Examination of the cervical ICA is not part of the STOP trial and related recommendations. There is, however, increasing evidence that extracranial carotid artery (eICA) stenosis in children with sickle cell disease is an independent risk factor for silent cerebral infarction. Although there is no agreed level to classify an eICA stenosis and velocities are affected by haemoglobin level and tortuosity, two techniques have been used in published data:

For non-imaging, use of a 2MHz phased array or TCD probe with a sub-mandibular approach, no angle correction, and a TAMMV of ≥ 160 cm/s.

For imaging use of a linear array with angle correction and a peak systolic velocity of ≥ 300 cm/s.

The current level of evidence indicates that scanning the eICA provides useful information on risk and that if high velocities are detected, clinicians should consider further investigations for vasculopathy and ischaemic lesions.

Training

All operators performing TCD or TCDi scanning on children must have had appropriate training in the technique. Training will be organised by the Lead TCD for each HCC and will incorporate three elements: -

- A training day on the theory of TCD scanning, protocols and equipment with demonstration and hands-on TCD scanning practice on adults/other trainees. 'Hands on' TCD training will be provided with children in a clinic environment. Further practice can be carried out locally but only under adequate supervision in a clinic environment.
- Trainees will be expected to keep a logbook showing records of the subjects scanned and the procedures undertaken. It would normally be expected that trainees will conduct and report at least 40 supervised TCD scans on children to gain competence in the technique, unless they are performing other vascular Doppler ultrasound scans routinely, which can contribute to 50% of the logbook scans.
- A final competency evaluation will be carried out either at the trainee's place of work or at the training centre. Successful trainees will be added to the TCD Practitioner Register held by the UK Forum and will also be granted access to the National Haemoglobinopathy Registry (NHR).

Quality assurance

Those centres undertaking TCD scanning must be part of a network of care for sickle cell children and be part of any national approval/accreditation process of those centres.

All TCD practitioners will be required to complete an annual QA return, confirming the number of scans performed to enable them to remain on the register. The guideline number of TCD scans to maintain proficiency is a minimum of 40 per year. It would be appropriate to consider refresher training for those operators performing fewer than this number. Network centres must determine the best way to provide enough staff to maintain a quality TCD service for the sickle cell population in their area.

All TCD practitioners are responsible for entering TCD data on the National Haemoglobinopathy Registry (NHR). This will enable scanning results to be correlated with clinical outcome and audit the effectiveness of the screening programme. This will form the second part of the quality assurance scheme to identify centres reporting unusual TCD results or clinical outcomes that differ from their peers.

[Nice.org.uk/guidance/qs58](https://www.nice.org.uk/guidance/qs58)

Patient information sheet

What is Transcranial Doppler (TCD) scanning?

TCD is a test that uses ultrasound to measure how fast the blood flows through the blood vessels within the brain. The machine detects the noise of the blood rushing through the vessels and uses this to measure the speed at which it is travelling. It is an extremely safe, easy, painless procedure and is the only way to detect an increased risk of stroke in children with sickle cell disease. A TCD scan is recommended for children with SCD from age 2 to 16 years.

Why does my child need a TCD scan?

In sickle cell disease, blood vessels can be damaged by the sickled cells sticking to the walls. This causes the blood vessels to narrow and potentially close. If this happens in the brain, the blood gets cut off, starving the brain of oxygen and causing a stroke.

What is a stroke?

A stroke is when the oxygen flow to part of the brain is reduced. This causes weakness in an arm or leg, difficulty talking or understanding what is said and/or memory problems. These problems may either be short-lived or permanent. Strokes can happen more than once.

What happens during the TCD scan?

The test is done by a specialist TCD practitioner in either an imaging department or in the sickle clinic. No preparation is required beforehand.

The scan takes about 15 minutes, during which time your child will be asked to lie on a couch and keep still. He/she will be awake, and you may stay with them throughout the scan.

The ultrasound scanner transducer will be placed over the side of your child's head and flow velocities will be recorded. Afterwards you will be able to go straight home, although if the test is done in the sickle clinic, the Clinician will be there to discuss the results with you.

What do the results mean?

The results can be normal, conditional or abnormal.

- A **normal** result means that nothing needs to be done now, but the test will be repeated each year.
- A **conditional** result will mean that the scan should be repeated within three months.

An **abnormal** result means that there is an increased risk of having a stroke in the future. If the result is **abnormal**, the scan will be repeated within a month and other tests may be arranged, such as an MRI (Magnetic Resonance Imaging) scan or a special x-ray. Neither of these will be painful for your child. All the results will be sent to your Clinician for discussion with you.

What happens next?

Research has shown that giving a child regular blood transfusions (about every four weeks) can substantially reduce the risk of a future stroke. If your child's TCD results are abnormal and you consent to treatment, they should start regular blood transfusions as soon as possible.

How long will the transfusions continue for?

The increased risk of stroke is highest between the ages of two and 16 (peaking at seven years of age). However, studies have shown that even when the blood flow is back to normal the increased risk of stroke remains, so it is likely that your Clinician will continue with transfusions in the long term. Treatment options include hydroxycarbamide which will be discussed with you.

What if I think my child has had a stroke?

We know that one in 10 children with sickle cell anaemia (HbSS or HbS β 0) will have developed stroke by the age of 14 if nothing is done about it. It is important to report any symptoms of a stroke such as:

- weakness in an arm or leg
- difficulty speaking and/or understanding,
- memory problems.

You should see a doctor immediately, even if you are on holiday, so that tests can be carried out to find out whether your child has had or is having a stroke. If a stroke is confirmed, you will be offered regular transfusions to help prevent further strokes in the future.

What if I have more questions?

The haemoglobinopathy team is available to answer any questions or concerns you may have.

References

Adams RJ, McKie VC, Brambilla D, Carl E, Gallagher D, et al. Stroke Prevention Trial in Sickle Cell Anaemia (1998). *Control Clin Trials* Feb; 19(1): 110-29.

Adams RJ. Lessons from the Stroke Prevention Trial in Sickle Cell Anemia (STOP) study (2000). *J. Child Neurol.* May; 15(5):344-9. Review.

Adams RJ. Brambilla D. Optimizing Primary Stroke Prevention in Sickle Cell Anemia (STOP 2) Trial Investigators. Discontinuing prophylactic transfusions used to prevent stroke in sickle cell disease (2005). *N Engl J Med.* Dec 29;353(26):2769-78.

Bernaudin F, Verlhac S, Arnaud C, Kamdem A, Vasile M et al (2015). Chronic and acute anemia and extracranial internal carotid stenosis are risk factors for silent cerebral infarcts in sickle cell anemia. *Blood* 5;125(10).

Deane CR, Goss D, Bartram J, Pohl K, Height SE, Sibtain N, Jarosz J, Thein SL, Rees DC. Extracranial internal carotid arterial disease in children with Sickle Cell anaemia. *Haematologica* Aug 10;95(8):1287-92. Epub 2010 Mar 10.

Kwiatkowski J, Granger S, Brambilla DJ, Brown C, Miller ST & Adams RJ (2006). Elevated blood flow velocity in the anterior cerebral artery and stroke risk in sickle cell disease: extended analysis from the STOP trial. *Br J of Haematology*, 134:333-339.

Lee MT, Piomelli S, Granger S, Miller ST, Harkness S, Brambilla D & Adams RJ (2006). Stroke Prevention Trial in Sickle Cell Anaemia (STOP): extended follow-up and final results. *Blood* 1, Aug Vol 108;(3).

Padayachee TS, Thomas N, Arnold AJ & Inusa BI (2011). Problems with implementing a standardised Transcranial Doppler screening programme: impact of instrumentation variation on STOP classification. *Pediatric Radiology*; 42(4):470-4.

Ware RE, Davis BR, Schultz WH, et al. (2016). Hydroxycarbamide versus chronic transfusion for maintenance of transcranial doppler flow velocities in children with sickle cell anaemia—TCD With Transfusions Changing to Hydroxyurea (TWITCH): a multicentre, open-label, phase 3, non-inferiority trial. *Lancet* 2016; 387: 661–70

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