Alder Hey Children's NHS Foundation Trust

Management of stroke in childhood- clinical guideline for diagnosis and management of acute ischaemic stroke in childhood

Introduction

This document is aimed at medical and nursing staff in hospital looking after patients presenting with symptoms or signs suggestive of an acute ischaemic stroke. It is based on the national NICE accredited guideline from the RCPCH 2017 guideline Stroke in Childhood http://www.rcpch.ac.uk/stroke-guideline

Background

Stroke is a serious childhood disorder, affecting several hundred children and young people in the UK each year. At least half of the survivors have some long-term impairment. The full impact of stroke on the developing brain may only emerge over time, with increasing demands on neurocognitive functions, and on educational and social roles, resulting in widespread and long-lasting impact on personal, family and societal consequences.

Treatment of acute ischaemic stroke with thrombolysis or thrombectomy should be considered in a selected group of children presenting with acute ischaemic stroke. There is a paucity of evidence in paediatric stroke, the RCPCH guideline has been produced with expert consensus.

Diagnosis

Acute diagnosis of stroke in childhood.

Clinical presentation

Use FAST (face, arms, speech, time) criteria to determine stroke in children and young people, but do not rule out stroke in the absence of FAST signs. Undertake urgent brain (CT +/- CTA) imaging of children and young people presenting with one or more of the following symptoms. (MRI brain and MRA could be considered instead of CT scan if feasible and available within one hour of arrival in hospital)

- Acute focal neurological deficit, aphasia, reduced level of consciousness (age appropriate Glasgow coma scale GCS less than 12) or AVPU (Alert, Voice, Pain, Unresponsive) scale (less than V at presentation).

- Consider urgent brain imaging (CT+/- CTA) for children and young people presenting with the following symptoms which *may* be indicative of stroke: - new onset focal seizures, new onset severe headache, altered mental status including transient loss of consciousness or behavioural changes, new onset ataxia, vertigo or dizziness - sudden onset of neck pain or stiffness - witnessed acute focal neurological deficit which has since resolved.
- Be aware that the following non-specific symptoms can be present in a child presenting with stroke: - nausea +/-vomiting and fever
- Be aware that acute focal neurological signs may be absent and that attention should be given to parental or young person concerns about the presentation of unusual symptoms.
- Ensure that a cranial computerized tomography (CT) scan is performed within 1 hour of arrival at hospital or symptom onset in an inpatient in hospital in every child with a suspected stroke. This should include: - computerized tomography angiography (CTA) (covering aortic arch to vertex) if the CT scan does not show haemorrhage ***OR*** - CTA limited to intracranial vascular imaging, if haemorrhagic stroke (HS) is demonstrated.
- Requesting of CT should be by a senior decision maker of registrar grade or above (ED or paediatrics) who has assessed the patient clinically in person. The scan should be requested by contacting the radiology team in working hours or the on call neuroradiology consultant/registrar covering CT
- Consider primary imaging using magnetic resonance imaging (MRI) in suspected stroke only if it is available within 1 hour of arrival at hospital.
- Initial scan images should be reviewed on acquisition and discussed with the radiologist on call. If scan is suggestive of infarction with occlusion of middle cerebral artery (MCA) or basilar artery (BA) seen on CT and CTA, consider suitability for emergency interventions such as thrombolysis or mechanical thrombectomy or decompressive craniectomy (in case of haemorrhagic stroke and in that case discuss with neurosurgery)
- Consider thrombolysis (only if child presents within 4.5 hrs) or mechanical thrombectomy (can be done upto 24 hrs). Please discuss with oncall Radiologist.
- Arrange MRI in a clinically timely manner for both patients with acute ischaemic stroke and haemorrhagic stroke for improved diagnostic resolution, if not obtained in/at the initial imaging investigation.
- Arrange MRI within 24 hours if initial CT is negative and stroke is still suspected. Be aware that 70% of acute ischaemic strokes in childhood are not evident on initial CT imaging. Discuss early with neuroradiology.
- Consider adding magnetic resonance angiogram (MRA) at the time of undertaking MRI: this should cover the aortic arch to vertex in arterial

ischaemic stroke and can be limited to the intracranial circulation in haemorrhagic stroke.

- Please discuss all requests for MRI imaging with the on call neuroradiology consultant. Acute management includes clinical algorithm, poster and clinical algorithm from RCPCH website https://www.rcpch.ac.uk/sites/default/files/2018-04/2017_stroke_in_childhood_-_pathway_poster.pdf).

Identify children with suspected stroke

1 Identify potential stroke

- Acute focal neurological deficit
- Speech disturbance
- Unexplained, persistent change in conscious level (GCS < 12 **OR** AVPU < V)

Also consider stroke in children with:

- New onset focal seizures
- New onset severe headache
- Ataxia
- Dizziness
- Resolved acute focal neurological deficit
- Sickle Cell Disease

Neurological assessment

PedNIHSS definitions	Scale definition
1a. Level of Consciousness:	**0** = Alert; keenly responsive **1** = Not alert, but arousable by minor stimulation **2** = Not alert, requires repeated stimulation to attend, or is obtunded and requires strong or painful stimulation to make non-stereotyped movements **3** = Responds only with reflex motor or autonomic effects or totally unresponsive
1b. LOC Questions:	**0** = Answers both questions correctly **1** = Answers one question correctly **2** = Answers neither question correctly
1c. LOC Commands:	**0** = Performs both tasks correctly **1** = Performs one task correctly **2** = Performs neither task correctly
2. Best Gaze:	**0** = Normal **1** = Partial gaze palsy **2** = Forced deviation / complete gaze palsy
3. Visual:	**0** = No visual loss **1** = Partial hemianopia **2** = Complete hemianopia **3** = Bilateral hemianopia (including cortical blindness)
4. Facial Palsy:	**0** = Normal symmetrical movement **1** = Minor paralysis (flattened nasolabial fold, asymmetry on smiling) **2** = Partial paralysis (total or near total paralysis of lower face) **3** = Complete paralysis of one or both sides
5 & 6. Motor Arm and Leg:	**5a. Left Arm, 5b. Right Arm** **0** = No drift for full 10 seconds **1** = Drift < 10 seconds **2** = Some effort against gravity **3** = No effort against gravity **4** = No movement **5** = Amputation **6a. Left Leg, 6b. Right Leg** **0** = No drift for full 5 seconds **1** = Drift 5 seconds **2** = Some effort against gravity **3** = No effort against gravity **4** = No movement **5** = Amputation
7. Limb Ataxia:	**0** = Absent **1** = Present in one limb **2** = Present in two limbs
8. Sensory:	**0** = Normal; no sensory loss **1** = Mild to moderate sensory loss **2** = Severe to total sensory loss
9. Best Language:	**0** = Normal **1** = Mild to moderate aphasia **2** = Severe aphasia **3** = Mute, global aphasia

2 Pre-hospital care: Ring 999 / 111

- Manage Airway
- Administer high flow O_2 if clinically indicated
- Perform a capillary glucose test within 15 minutes of presentation
- Treat HYPOGLYCAEMIA (if capillary blood glucose 3 mmol/L give 2 ml/kg of 10% dextrose)
- Assess using **FAST**
- Transport to nearest ED with acute paediatric services
- Priority call / pre-alert ED of impending arrival of child with suspected stroke
- Activate (locally defined) acute paediatric stroke pathway
- If Sickle Cell Disease is suspected, discuss with paediatric haematologist who should be present in pre-hospital care / ED

3 ED: Activate acute stroke pathway

[illegible]

- Intubate if GCS < 8, AVPU = U, if there is a loss of airway reflexes or there is suspected / proven raised intracranial pressure
- Administer high flow O_2 and target SpO_2 ≥ 92%
- If the circulation is compromised give a 10 ml/kg isotonic fluid bolus
- Perform a capillary glucose test within 15 minutes of presentation. If capillary blood glucose 3 mmol/L give 2 ml/kg of 10% dextrose and consider a hypoglycaemia screen

4 Investigations

- Venous or capillary blood gas
- FBC, PT, APTT
- Fibrinogen
- Urea and electrolytes
- Blood glucose
- Group and save
- C-reactive protein
- Liver function tests
- Blood cultures as appropriate

Monitoring

- BP
- Temperature
- SpO_2
- HR
- RR
- GCS
- Assess PedNIHSS score

See 'Neurological assessment'

5 Urgent brain imaging

Perform CT / CTA < 1 Hour of ED admission

Record time of symptom onset
Window for tPA = 4.5 hours

Record time of admission
Window for imaging = 1 hour

6 Stroke mimic

MRI with stroke-specific sequences should be performed in patients with suspected stroke when there is diagnostic uncertainty.

Haemorrhagic stroke

Urgent discussion with neurosurgical team regarding need for transfer.

Arterial ischaemic stroke

Consider suitability for other emergency interventions, such as: Thrombectomy or Decompressive craniectomy.

7 Treatment for Arterial ischaemic stroke (AIS)

Aspirin

- 5mg/kg < 1 hour (Unless CI, e.g. parenchymal haemorrhage)
- Delay for 24 hours in context of thrombolysis

In children presenting with AIS Thrombolysis, the use of tPA...
may be considered if 2–8 years and ***could*** be considered if ≥ 8 years

IF ALL OF THE FOLLOWING ARE TRUE:

- PedNIHSS ≥ 4 and ≤ 24
- tPA can be administered ≤ 4.5 hours of symptom onset
- CT has excluded intracranial haemorrhage
- CTA demonstrates normal brain parenchyma or minimal early ischaemic change
- CTA demonstrates partial / complete occlusion of the intracranial artery corresponding to clinical / radiological deficit

OR

- MRI and MRA showing evidence of acute ischaemia on diffusion weighted imaging + partial / complete occlusion of the intracranial artery corresponding to clinical / radiological deficit

PROVIDING THAT THERE ARE NO CONTRAINDICATIONS

NICE accredited

Produced in line with the full RCPCH clinical guideline.
For further details on all recommendations, visit: www.rcpch.ac.uk/stroke-guideline

- **PLEASE NOTE THAT CHILDREN WITH CARDIAC DISEASE WITH NEW ONSET NEUROLOGICAL SYMPTOMS SHOULD BE CONSIDERED TO HAVE HAD A STROKE UNTIL PROVEN OTHERWISE**
- Monitor blood pressure, temperature, oxygen saturation, heart rate and respiratory rate in all children and young people presenting with a clinical diagnosis of stroke.
- Use the Ped NIHSS and age-appropriate GCS or AVPU to assess the child's neurological status and conscious level respectively (see algorithm/appendix B for assessment of PedNIHSS including scoring).
- Withhold oral feeding (eating and drinking) until the swallow safety has been established.
- Maintain normal fluid, glucose and electrolyte balance.
- Target oxygen saturations above 92%.
- Treat hypotension.
- Consider the cause and the need for treatment of hypertension in haemorrhagic stroke on a case by case basis only in discussion with the neurosurgical team.
- Children and young people with acute ischaemic stroke should only receive blood pressure lowering treatment in the following circumstances:

  - in patients who are otherwise eligible for intravenous IV thrombolysis but in whom systolic blood pressure exceeds 95th centile for age by more than 15%,
  - or has hypertensive encephalopathy / end organ damage or dysfunction e.g. cardiac or renal failure.

Risk factors for first AIS

- Be aware that the following conditions/factors are associated with an increased risk of AIS in children and young people, as tabulated:

Risk Category	Included factors/diagnoses
Arteriopathy	• focal cerebral arteriopathy of childhood • moyamoya • arterial dissection • central nervous system (CNS) vasculitis
Cardiac disease	• congenital cardiac disease • additional risk factors in children and young people with cardiac disease: Right to Left shunt, increased, Lipoprotein(a) (Lp(a)), anticardiolipin antibody (ACLA), combined prothrombotic disorders
Cardiac surgery/interventions	
Sickle Cell Disease	Additional factors in children and young people with SCD: • genotype (sickle haemoglobin (HbS) & HbSβ thalassaemia more than other genotypes) • abnormal transcranial Doppler studies • arteriopathy (intracranial & extracranial) • absence of alpha thalassaemia trait • acute anaemia • silent infarction

	• prior transient ischaemic attack (TIA) • high systolic blood pressure, acute chest syndrome • anaemia, high reticulocyte count
Infection	• varicella zoster • upper respiratory tract infections • multiple infections
Gender/Ethnicity	• black ethnicity • Asian ethnicity • male gender
Thrombophilia	• genetic: Factor V Leiden (FVL), PT20210, MTHFR c677T, protein C deficiency, increased lipoprotein(a) (Lp(a)), more than 2 genetic thrombophilia traits, high homocystinuria (HCY) • acquired: antiphospholipid syndrome (APLS)
Miscellaneous	• iron deficiency anaemia • radiotherapy • high alpha 1 antitrypsin (AT), trauma • under-vaccination • multiple risk factors

- Consider the following conditions which are linked with childhood AIS and may be clinically important in relevant cohorts (although have not been scrutinised in case-control analyses):
  - trisomy 21
  - neurofibromatosis
  - malignancy and long-term effects of treatment for malignancy (especially cranial radiotherapy)
  - auto-immune diseases, e.g. systemic lupus erythematosus
  - illicit drugs and other recreational drugs (e.g. cocaine)

- The importance of Fabry disease in children and young people has not been investigated but is treatable and implicated in young adults and until this is resolved should be considered in the work-up.

- Take these factors into account when considering a need for counselling in high-risk groups.

- Information on risk factors should be delivered in face-to-face conversation

- Carry out the following investigations in children and young people with a diagnosis of AIS:
  - haematological investigations, including full blood count, iron status (e.g. iron, ferritin, total iron binding capacity) and haemoglobinopathy screen
  - biochemistry tests, including total plasma homocysteine, alpha galactosidase, fasting blood sugar, fasting cholesterol, and Lipoprotein(a)
  - lupus anticoagulant and ACLA, and discuss beta 2GP1 testing with haematology if necessary
  - cardiac evaluation: electrocardiogram (ECG), echocardiogram (to identify structural lesions and R to L shunts)
  - cerebrovascular imaging from the aortic arch to vertex, with computed tomography angiography (CTA) or magnetic resonance angiogram (MRA) at the time of CT or MRI respectively
  - transcranial Doppler in patients with SCD

- Clinically evaluate all patients for history of prior infection (especially VZV), immunisation, dysmorphic features, neurocutaneous stigmata, autoimmune disease and evidence of vascular disease in other organ systems.

Treatment/Management

Acute medical interventions for acute ischaemic stroke

Use of thrombolysis or anti-thrombotic therapy.

- Start on aspirin 5 mg/kg (maximum of 300 mg) within 24 hours of diagnosis of AIS in the absence of contraindications (e.g. parenchymal haemorrhage). After 14 days reduce dose of aspirin to 1 mg/kg (maximum 75 mg.)
- Delay starting aspirin for 24 hours in patients where thrombolysis has been given.
- Aspirin should **not** be routinely given to children and young people with sickle cell disease (SCD) presenting with AIS.
- In children and young people with cardiac disease presenting with AIS, make a multi-disciplinary decision (including haematologists, paediatric neurologists and cardiologists) regarding the optimal anti-thrombotic therapy, anti-platelet versus anticoagulation with assessment of the risk benefit in individual cases.

Treatment/Management continued

Acute medical interventions for acute ischaemic stroke

Alteplase (tissue plasminogen activator (tPA) may be considered in children presenting with AIS who are more than 8 years of age and may be considered for children aged between 2 & 8 years of age, on a case-by-case basis when the following criteria have been met:

AIS has occurred as defined by:

- An acute focal neurological deficit consistent with arterial ischaemia

AND

- Paediatric National Institute of Health stroke scale (PedNIHSS) more than or equal to 4 and less than or equal to 24,

AND

- Intracranial haemorrhage has been excluded
- CT and CTA demonstrates normal brain parenchyma or minimal early ischaemic change and demonstrates partial or complete occlusion of the intracranial artery corresponding to clinical or radiological deficit

OR

- MRI and MRA showing evidence of acute ischaemia on diffusion weighted imaging **PLUS** partial or complete occlusion of the intracranial artery corresponding to clinical or radiological deficit

AND

- **Alteplase treatment can be administered within 4.5 hours of known onset of symptoms providing that there are no contraindications.**
- Begin thrombolysis irrespective of patient location at the point of AIS diagnosis and when above criteria are fulfilled.

Treatment using tPA (Alteplase)

Alteplase has been licensed in Europe since 2002 for the treatment of acute ischaemic stroke in adults. It is not licensed in children under 16 years but may be used after discussion with paediatric neurology, paediatric neuroradiology and parents.

- Who might need to be involved in caring for these patients?

The paramedics and nurses in the emergency department (ED) or ward-based staff will identify patients and initiate all necessary interventions and ensure that acute monitoring occurs.

If an acute ischaemic stroke is identified, this should be discussed with paediatric radiology, paediatric neurologist on call (if available) and neurosurgeons if appropriate to decide on appropriate treatment with either Alteplase or thrombectomy.

- What are the risks of thrombolysis?

The major adverse effects is the risk of symptomatic intracerebral haemorrhage. Other sorts of bleeding may occur e.g., gastrointestinal or from injection sites. Very rarely allergic reactions can occur.

- How can the risks be minimized?

The risks can be minimized by careful selection of patients who meet the criteria for thrombolysis. There is a check list of inclusion and exclusion criteria (see appendix 3) which includes an emergency CT scan to rule out a haemorrhage. There are intensive post alteplase monitoring requirements which are designed to pick up any early signs of side effects developing.

- What do the ED staff do if they identify somebody with a potential stroke?

Unlike in adult services, there is no brain attack team in paediatrics (patient's ≥16 years should be referred to the brain attack team). Therefore, the emergency department staff will be responsible for organising brain imaging within an hour of arrival in the department. They will be responsible for resuscitation and stabilisation of the patient, sending off a standard panel of initial investigations and contacting the on call neuroradiologist for an emergency scan.

- What happens if the patient is deemed potentially suitable for thrombolysis or thrombectomy?

This patient should be discussed with the paediatric neuroradiologist and paediatric neurologist on call. They should be checked with the thrombolysis protocol proforma that the patient meets all inclusion and exclusion criteria (appendix 3). The risks and benefits of thrombolysis must be discussed with the patient and/or relative.

- What is the role of mechanical thrombectomy?

A clot retrieval procedure may be considered as an adjunct therapy to thrombolysis in selected patients or rarely if intravenous thrombolysis is not appropriate. Evidence indicates that in proximal large vessel occlusion, thrombectomy leads to a better functional outcome than medical management alone. If large vessel occlusion is suspected clinically or radiologically, a CT angiogram may be undertaken to demonstrate a treatable clot.

The following is relevant for Alder Hey Children's Hospital. This may vary according to local practices at different District General Hospital sites:

- Where will the thrombolysis be carried out?

Thrombolysis – at Alder Hey, this will be carried out in one of the resuscitation bays in the ED. This will reduce any delay in administering the medication. The Alteplase is stored in the night room in ED (Alder Hey). Detailed instructions on dosage, administration and monitoring for Alteplase are available (for Alder Hey) in Document Management System (DMS) under injectable therapy guidelines.

- Who will be responsible for administering the medication?

The medication will be administered by senior member of the attending team.

- Who will decide on thrombolysis?

The ultimate decision to thrombolyse a patient will be made by the leading attending Consultant following discussion with all the available senior members of the multidisciplinary team i.e. Emergency Department, General Paediatrics, Radiology/ Interventional Radiology, Neurorosurgery and Neurology depending on availability.

Contraindications to thrombolysis

Exclusion criteria for IV tPA (based on the Thrombolysis in Pediatric Stroke Study[7], for further information see http://stroke.ahajournals.org/content/46/3/880/tab-figures-data).

- Unknown time of symptoms onset
- Pregnancy
- Clinical presentation suggestive of subarachnoid haemorrhage (SAH), even if brain imaging is negative for blood
- Patient who would decline blood transfusion if indicated
- History of prior intracranial haemorrhage
- Known cerebral arterial venous malformation, aneurysm or neoplasm
- Persistent systolic blood pressure more than 15% above the 95th percentile for age while sitting or supine
- Glucose less than 2.78mmol/L or more than 22.22mmol/L
- Bleeding diathesis including platelets less than 100 000, prothrombin time (PT) more than15s (international normalised ratio (INR) more than 1.4), or elevated activated partial thromboplastin time (aPTT) more than upper limits of the normal range
- Clinical presentation consistent with acute myocardial infarction (MI) or post-MI pericarditis that requires evaluation by cardiology before treatment
- Prior stroke, major head trauma, or intracranial surgery within the past three months
- Major surgery or parenchymal biopsy within 10 days (relative contraindication)
- Gastrointestinal or urinary bleeding within 21 days (relative contraindication)

- Arterial puncture at non-compressible site or LP within seven days (relative contraindication). Patients who have had a cardiac catheterization via a compressible artery are not excluded
- Patient with malignancy or within one month of completion of treatment for cancer
- Patients with an underlying significant bleeding disorder. Patients with a mild platelet dysfunction, mild von Willebrand disease, or other mild bleeding disorders are not excluded
- Stroke related exclusion criteria:
  - Mild deficit (Paediatric National Institute of Health Stroke Scale (PedNIHSS) less than 4) at start of tPA infusion or at time of sedation for neuroimaging, if applicable
  - Severe deficit suggesting large territory stroke, with pre-tPA PedNIHSS more than 24, regardless of the infarct volume seen on neuroimaging
  - Stroke suspected to be because of subacute bacterial endocarditis, moyamoya, sickle cell disease, meningitis, bone marrow, air, or fat embolism
  - Previously diagnosed primary angiitis of the central nervous system (PACNS) or secondary central nervous system (CNS) vasculitis. Focal cerebral arteriopathy of childhood is not a contraindication
- Neuroimaging related exclusions:
  - Intracranial haemorrhage on pre-treatment head CT and MRI
  - Intracranial dissection (defined as at or distal to the ophthalmic artery)
  - Large infarct volume, defined by the finding of acute infarct on MRI involving one-third or more of the complete middle cerebral artery (MCA) territory involvement
- Drug-related exclusions:
  - Known allergy to recombinant tissue plasminogen activator
  - Patient who received heparin within four hours must have activated partial thromboplastin time (aPTT) in normal range
  - Low molecular-weight heparin (LMWH) within past 24 hours (aPTT and INR will not reflect LMWH effect)

Acute AIS treatment in children and young people with Sickle Cell Disease (SCD)

- Treat children and young people with SCD and acute neurological signs urgently with a blood transfusion, to reduce the HbS to 30% and increase the haemoglobin concentration to more than 100-110g/l. This will usually require exchange transfusion.
- Provide a small top up transfusion to bring Hb to 100g/l to improve cerebral oxygenation if the start of the exchange is likely to be delayed by more than 6 hours
- Provide other standard supportive stroke care
- Prioritise exchange transfusion over thrombolysis

Medical interventions to prevent recurrence of AIS

- Continue antithrombotic treatment initiated acutely in children and young people with AIS. Reduce dose of aspirin from 5mg/kg to 1mg/kg after 14 days.
- Treat all children and young people with AIS with aspirin, unless they have SCD or are receiving anticoagulation e.g. for a cardiac source of embolism.
- In patients with cardiac disease the choice of antithrombotic agent should be decided on a case-by-case basis following discussion between the treating neurologist and cardiologist.
- Duration of antithrombotic treatment should be considered on a case-by-case basis depending on risk factors identified.
- Maintain adequate levels of hydration in patients with occlusive arteriopathies including moyamoya, especially when fasting or during intercurrent illness.

AIS recurrence prevention in SCD

- Start regular blood transfusions as secondary stroke prevention in children and young people with SCD, aiming to keep the pre-transfusion HbS less than 30% and keeping the pre-transfusion haemoglobin above 90g/l. This can be done with either exchange or simple top-up blood transfusion.

- Ensure that all children and young people with SCD and their siblings are HLA typed. Children and young people with HLA-identical siblings and recurrent stroke or worsening vasculopathy despite optimum haematological treatment should be referred for discussion of HSCT.

- Monitor children with regular neurocognitive testing, MRI and TCD; frequency should be determined on a case-by-case basis.

- Intensify treatment if there is evidence of progressive cerebrovascular disease, if identified through either TCD or magnetic resonance angiography. Options may include:
  - intensified transfusion with lower HbS target
  - the addition of hydroxycarbamide or antiplatelet agents during red cell transfusions
  - consideration of surgical revascularisation (in the presence of arteriopathy)
  - referral for alternative-donor HSCT

- Children and young people's cases should be discussed in an appropriate multidisciplinary team (MDT) with experience of managing children and young people with SCD prior to referral for either surgery or alternative-donor HSCT.

- Hydroxycarbamide should be considered as part of a secondary stroke prevention programme when suitable blood (e.g. multiple alloantibodies or hyperhaemolysis) is not available, or when continued transfusions pose unacceptable risks (uncontrolled iron accumulation).

- Hydroxycarbamide may be used as an alternative to blood transfusion if transfusion is genuinely unacceptable to the parents/carers and child. It is imperative that the decision to stop transfusions and switch to hydroxycarbamide is taken by a MDT.

- Consider using anticoagulation or antiplatelet agents only when there are other risk factors for cerebrovascular disease that justify their use.

SCI progression prevention in SCD

- Discuss the possible benefits of transfusion with children, young people and families if SCI are identified on MRI. Factors favouring the implementation of a treatment program involving regular blood transfusions include:
  - impaired cognitive performance
  - progressive deterioration in cognitive function
  - evidence of increase in size or number of SCIs on serial MRIs
  - evidence of intracranial or extracranial vasculopathy on MRA
  - other co-existent morbidities of SCD which may benefit from regular blood transfusions, including frequent episodes of acute pain, progressive pulmonary damage, and progressive renal impairment.

- Consider haematopoietic stem cell transplantation in children and young people starting transfusions.

- Consider starting hydroxycarbamide as an alternative therapy if repeated transfusions are declined or contra-indicated.

Indications for referral to neurosurgery in children and young people with AIS

- Discuss any impairment of conscious level or decline in PedNIHSS in a child with AIS with a neurosurgical team.

- Consider decompressive hemicraniectomy in children and young people with MCA infarction under the following circumstances:
  - neurological deficit indicates infarction in the MCA territory
  - surgical treatment can be given less than or equal to 48 hours after the onset of stroke
  - a decrease in the level of consciousness to a score of 1 or more on item 1a of the PedNIHSS

  - PedNIHSS score of more than 15
  - while not validated in children, signs on CT of an infarct of at least 50% of the MCA territory with or without additional infarction in the territory of the anterior or posterior cerebral artery on the same side.

- If a patient meets the above circumstances and is not already in a neurology unit, they should be ventilated and neuroprotected and moved to the neurological unit as time critical transfer.

- Consider performing decompressive craniectomy in vascular infarctions in other territories, e.g. posterior fossa infarction.

- Refer children and young people with moyamoya to a paediatric neurosurgical centre with expertise in surgical revascularisation.

- Consider surgical revascularisation in patients with moyamoya and ongoing ischaemic symptoms or other risk factors for progressive disease.

.

Surgical and vascular interventions for acute ischaemic stroke

Indications for referrals to interventional neuroradiology.

- Patients with acute AIS causing a disabling neurological deficit (PedNIHSS score of 6 or more) may be considered for intra-arterial clot extraction with prior IV thrombolysis, unless contraindicated, beyond an onset-to-arterial puncture time of 5 hours if:
- PedNIHSS score is more than 6
- A favourable profile on salvageable brain tissue imaging has been proven, in which case treatment up to 12 hours after onset may be appropriate.

Surgical intervention for AIS/ Indications for referral to neurosurgery in children and young people with AIS –

- Discuss impairment of conscious level or decline in PedNIHSS in a child with AIS with the neurosurgical team.
- Consider decompressive hemicraniectomy in children and young people with middle cerebral artery (MCA) infarction under the following circumstances:
- neurological deficit indicates infarction in the MCA territory.
- surgical treatment can be given less than or equal to 48 hours after the onset of a stroke.
- a decrease in the level of consciousness to a score of 1 or more on item 1a of the PedNIHSS
- PedNIHSS score of more than 15
- Signs on CT of an infarct of at least 50% of the MCA territory, with or without additional infarction in the territory of the anterior or posterior cerebral artery on the same side. (not validated in children)
- In vascular infarctions in other territories for example posterior fossa infarction, decompressive craniectomy may be considered and should be discussed with the neurosurgical team.

Haemorrhagic stroke

Haemorrhagic stroke (HS) like arterial ischaemic stroke in children and young people has a different risk factor profile to adults. Structural causes are more common. (eg AVM, aneurysms, cavernous malformations, arteriopathy with moya moya, sickle cell disease. Bleeding disorders may also present with childhood HS.

Risk factors for first HS

- Be aware that the following factors/conditions are associated with an increased risk of HS in children and young people, as tabulated:

Risk Category	Included factors/diagnoses
Vascular disorders	• AVM, especially with arterial phase aneurysms, varicosities or venous stenoses on the draining veins • cavernous malformations, especially Zabramski type 1 & 2 • cerebral arterial aneurysms

	• moyamoya
Clotting disorders	• severe platelet disorders/low platelet count • all severe inherited bleeding disorders • anticoagulation • severe vitamin K deficiency
Sickle Cell Disease	
Illicit drug use	• amphetamines • cocaine
Gender/ethnicity/age	• age 15 to 19 years • black ethnicity • male gender

- Take these factors into account when considering a need for counselling in high risk groups.

- Information on risk factors should be delivered in face-to-face conversation with parents/carers and young people (where appropriate) and supported where possible with web-based or written materials for later reference. The information provided should be age-appropriate and multi-format.

Risk factors for recurrent HS

- Be aware of increased risk of recurrence in children and young people with HS and the following risk factors:
  - AVM
  - cerebral arterial aneurysms
  - cavernous malformations
  - moyamoya
  - SCD
  - all severe bleeding disorders
  - ongoing anticoagulation
  - illicit drug use e.g. amphetamines and cocaine

- Be aware that in arteriovenous malformations, which have already bled, the greatest risk of a rebleed is from the part of the malformation which was responsible for the initial haemorrhage. Intranidal or perinidal aneurysms and venous varicosities/stenoses are sinister features.

- Carry out the following investigations in children and young people diagnosed with HS:
  - Haematological investigations:
    - coagulation screen including activated partial thromboplastin time (aPTT), prothrombin time (PT), fibrinogen (ideally by Clauss method) (taken by a free-flowing venous sample), full blood count (FBC), haemoglobinopathy screen.
    - discuss any abnormality of these haematological tests with a paediatric haematologist so that they can advise on further testing including specific clotting factor assays.
    - establish whether the parents are consanguineous as there are some rare severe recessive bleeding disorders that cannot be ruled out with a normal blood count and coagulation screen.
  - Imaging investigations:
    - discuss the child's case in a neurovascular multidisciplinary team (MDT) to plan further investigations to identify/exclude underlying vascular malformation and to plan any interventional treatment; such investigations may include non-invasive angiography such as computed tomography angiography (CTA) or MRA, as well as formal catheter angiography (CA)

- If the child is known to have SCD, additional tests should include transcranial Doppler ultrasonography (TCD) and an extended blood group phenotype (e.g. ABO, Rh C, D and E, and Kell).

Document Control Sheet

Title of Document	
Version:	
Ratified by:	Neurology Governance Meeting
Date ratified:	15/01/2024
Name of originator/author:	Dr R Karuvattil, Dr S Spinty
Approved by:	
Date approved:	
Date issued:	
Review date:	

Version Control Table				
Version	**Date**	**Author**	**Status**	**Comment**

Review & Amendment Log Record of changes made to document since last approved version			
Section Number	**Page Number**	**Change/s made**	**Reason for change**