Stroke Algorithm

DCMC Evidence-Based Outcomes Center

Inclusion Criteria:
Children (> 1 month of age to 18 years at time of presentation) with clinical presentation of sudden onset of Acute CNS Neurological Deficit, within 24 hours of symptom onset. (Ischemic Stroke, Primary Hemorrhagic Stroke, Cerebral Sinovenous Thrombosis)

Exclusion Criteria:
Perinatal Stroke: <1 month of age, traumatic brain injury, suspected stroke with symptom onset >24 hrs. Transient ischemic attack (TIA)

Procedures:
- Vital signs: Airway management, Pulse oximetry, real weight, temp, bp
- Establish two IV lines
- Treat if blood glucose <60 or >150 mg/dL
- Administer supplemental oxygen to maintain pulse ox >95%
- Treat temp >38° C w/acetaminophen
- Treat hyperglycemia to maintain glucose in a range of 140 - 180 mg/dL **and**
- Avoid hypoglycemia (glucose < 60 mg/dL)
- Treat seizure right away (See Status Epilepticus Pathway)
- Normotension - Systolic BP should be maintained between 50th and 15% above the 95th percentile for age.

Labs(STAT)
- CMP, CBC, PT/aPTT, Fibrinogen, Urinalysis, Quantitative d-dimer, hCG (in menarchal females), type & cross

Activity
NPO
Head of bed flat

Monitor
Temp, glucose, blood pressure, oxygen saturation

1

Clinical presentation with sudden onset of Acute CNS Neurological Deficit

General Assessment and Stabilization
Triage symptoms for suspected stroke
Stabilize Patient/order labs (STAT)
Initiate Level 1 Code Stroke Alert
Consider risk factors for stroke

1-2

This protocol triggers urgent evaluation by a neurologist and consideration of urgent imaging of the brain

Neurologic Assessment
1. Review patient history
2. Establish time of Last Known Normal
3. Perform neurological exam: PedNIHSS

Findings consistent with stroke? — No → Treat off algorithm

Yes

Emergent Imaging*/Labs
Limited MRI Brain is preferred (if immediately available)
OR
Non-contrast CT Brain/Head (STAT) (as Standard) and CTA Head/Neck

Notify ICU Attending with imaging results. Page others in Level 2 for Stroke Alert as needed

Stroke Confirmed? — No → Imaging negative for stroke → Evaluate for "Stroke Mimics"

Yes → CT/MRI evidence of bleeding? — Yes → **Evidence of Primary Hemorrhagic Stroke**

1. Consult Neurosurgery. Intervention will be joint decision btwn CT surgery and neuro surgery
2. Consult Hematology for suspected bleeding disorder workup

Prepare for emergent surgery (May need to notify cardiac anesthesia)

No → **Evidence of Ischemic Stroke** → Time since LKN/ symptom onset

< 4.5 h LKN

Non Large Vessel Occlusion (LVO) → **IV tPA** CANDIDATE**
Time from onset + estimated time to Arrival < 4.5 h, persistent focal deficit, and no contraindications to tPA

Large Vessel Occlusion (LVO) → IA tPA and/or Mechanical Thrombectomy

> 4.5 h LKN

Evaluation of endovascular intervention vs thrombolytic

Consider Mechanical Thrombectomy (see selection/exclusion criteria)

Consult neurosurgery attending on call as needed

No → **Evidence of Sinovenous Thrombosis**

1. Consult Neurology and Hematology for consideration of anticoagulation

Admit to PICU
Supportive Treatment

Level 1

PEDIATRIC STROKE ALERT
1. Neurology attending
2. Neuro-Imaging attending (to prepare for either reading the scan or doing the prep for MRI)
3. House Supervisor
4. CT/MRI Tech
5. Pharmacy
6. Interventional Radiology ***
7. PICU Attending & CN
8. Anesthesia (if sedation needed for MRI)

Level 2 - As Needed
1. Hematology ****
2. Neurosurgery (if Hemorrhagic)
3. PICU attending
4. Interventional Radiology
5. Pharmacy
6. NSG

(Level 2 individually paged on an AS NEEDED basis after initial imaging is done and stroke confirmed

2

*Brain MRI and vascular imaging MRA or CTA are available when clinically indicated to determine or guide treatment choices.
**At DCMC Alteplase is the thrombolytic of choice for Pediatric patients.
***Page during 1st Level if patient is considered high risk for embolism (e.g. major cardiac anomalies).
**** ALWAYS call for Sickle Cell patient
LKN – Last Known Normal

Stroke Order Set:
ED - ED Suspected Stroke Pedi
AC/PICU/CCU - Pedi Stroke
tPA – Stroke Thrombolytic Administration Pedi

Reference Materials:
- Exlcusion Criteria for IV tPA
- Alteplase for Acute Ischemic Stroke
- PedNIHSS

- Try to prioritize direct attending-to-attending communication when possible. This is especially important when there is uncertainty about a patient's presentation, the correct study to order, or a patient's candidacy for TPA.
- While MR is the preferred study for evaluating acute ischemic stroke, it may not be available 24/7 (especially in the middle of the night). In these cases, a non-contrast CT +/- CT angiography are the preferred studies. IT IS ESPECIALLY IMPORTANT TO HAVE A DISCUSSION WITH NEUROLOGY, RADIOLOGY ATTENDING IN THESE CASES.
- CT perfusion scan is a study which is available but it is predominantly used to help guide decisions on mechanical thrombectomy; it has a much higher dose of radiation and is only rarely an appropriate study for our population.

Goals:
1. Door to Needle within 60 minutes
   Refer to: Door to Needle Algorithm
2. MRI only if available within 60 min of arrival at hospital, otherwise, CT scan.

Last Updated 08.27.2021

Stroke Algorithm - Imaging

DCMC Evidence-Based Outcomes Center

Recommended imaging approaches for suspected hemorrhagic stroke, acute ischemic infarction, and cerebral venous sinus thrombosis.

Suspected Acute Hemorrhagic Stroke	**CT**	If the patient has an acute intracranial or subarachnoid hemorrhage, further cerebrovascular imaging (CTA, MRA, or catheter angiogram) may needed to identify the source of bleeding.
Suspected Acute Arterial Ischemic Stroke	**MRI**	If an acute stroke is identified, then add MRA brain and neck to look for arterial dissection.
Acute Cerebral Venous Sinus Thrombosis	**CT or MRI**	If a prior CT or MRI has already demonstrated a thrombus, then MRV can be used to identify the extent of occusion.
Studies to Assess Cerebral Perfusion	**CT or MRI**	

Imaging Notes

- Brain imaging should occur ASAP after a stroke.
- Additional imaging of the brain and/or vascular anatomy may be necessary & should be considered on a case-by-case basis.

MRI

- MRI is more sensitive to CT for early detection of Ischemic stroke
- MRI w/o contrast is preferred in suspected acute stroke cases that are <24 hours old
  - In cooperative patients, the MRI scan will be short (<10 minutes) and can be performed w/o sedation.
- MRI may be contraindicated or limited in patients with dental braces, ferromagnetic implants, pacing or stimulator wires.
- Protocol includes
  - Axial DWI
  - Axial T2 FLAIR
  - Optional: Axial SWI or MPGR (if no prior CT) to identify hemorrhage

Contact Imaging:

CT Scan 512-324-0000 x86484
Imaging Services Centralized Scheduling 512-324-1199
Imaging Services Main 512-324-0140

Back to Stroke Algorithm

Stroke Algorithm

DCMC Evidence-Based Outcomes Center

TABLE 1:

Risk Factors for Ischemic Stroke and CVST

Congenital Heart Disease
- Ventricular septal defect
- Atrial septal defect
- Aortic stenosis
- Mitral stenosis
- Coarctation of aorta
- Cardiac rhabdomyoma
- Complex congenital heart defects

Acquired Heart Disease
- Rheumatic heart disease
- Prosthetic heart valves
- Libman-Sacks endocarditis
- Infectious endocarditis
- Cardiomyopathy
- Myocarditis
- Atrial myxoma
- Arrhythmia

Systemic Vascular Disease
- Arterial hypertension
- Familial hyperlipidemias
- Volume depletion or hypotension
- Hypernatremia
- Diabetes mellitus

Vasculitis and Inflammatory
- Acquired immunodeficiency syndrome
- Behçet disease
- Meningitis
- Systemic infection
- Systemic lupus erythematosus
- Polyarteritis nodosa
- Granulomatous angiitis
- Takayasu's arteritis
- Rheumatoid arthritis
- Drug abuse (cocaine, amphetamines)
- Hemolytic-uremic syndrome
- Varicella infection

Vasculopathy
- Ehlers-Danlos type 4
- Moyamoya disease
- Fabry disease
- Malignant atrophic papulosis
- Neurofibromatosis type 1
- Post-irradiation
- Progeria
- Pseudoxanthoma elasticum
- Transient cerebral arteriopathy
- Williams syndrome

Hematologic/Coagulation Disorders
- Hemoglobinopathy (e. g. sickle cell disease)
- Fanconi anemia
- Thrombotic thrombocytopenic purpura
- Thrombocytosis
- Polycythemia
- Disseminated intravascular coagulation (DIC)
- L-asparaginase
- Leukemia or other neoplasm
- Oral contraceptives
- Pregnancy/postpartum period
- Antithrombin III deficiency
- Factor V Leiden mutation
- Hyperhomocysteinemia
- Nephrotic syndrome
- Protein S deficiency
- Protein C deficiency
- Prothrombin mutation
- Antiphospholipid antibodies
- Inflammatory bowel disease

Structural Vascular Anomalies
- Arterial fibromuscular dysplasia
- Arterial agenesis or hypoplasia
- Sturge-Weber syndrome
- Intracranial arterial aneurysm

Trauma
- Fat or air embolism
- Foreign body embolism
- Carotid ligation (e.g., with ECMO)
- Chiropractic manipulation
- Traumatic arterial dissection
- Blunt cervical or intraoral trauma
- Catheter angiography
- Carotid cavernous fistula
- Coagulation defect with minor trauma
- Amniotic fluid/placental embolism

Vasospastic Disorders
- Migraine
- Ergot poisoning
- Vasospasm & subarachnoid hemorrhage

Metabolic Disorders
- Homocystinuria
- Isovaleric acidemia
- MELAS
- Methylmalonic and propionic acidemia
- NADH-CoQ reductase deficiency
- Ornithine transcarbamylase deficiency

Risk Factors for Hemorrhagic Stroke

- Arteriovenous malformation or fistula
- Cavernous malformation
- Aneurysm
- Arterial hypertension
- Arteritis of cerebral vessels
- Infectious endocarditis
- Brain tumor
- Diabetic ketoacidosis
- Hypernatremia
- Hematologic disorders
- Sickle cell disease
    - Thrombocytopenia
    - Bone marrow transplantation
- Disseminated intravascular coagulation
    - Leukemia
- Coagulopathies
    - Afibrinogenemia
    - Hemophilia (Factor VIII or factor IX deficiency)
    - Factor VII deficiency
    - Factor XIII deficiency
    - Coagulopathy due to hepatic failure
    - Liver transplantation
    - Vitamin K deficiency
    - Maternal medications (e.g. phenobarbital, phenytoin)
    - Anticoagulant, antiplatelet, or thrombolytic agents
- Hemorrhagic infarction
- Venous sinus thrombosis
- Intracranial arterial dissection
- Moyamoya disease (more in adolescents and adults)
- Drug related (amphetamines, cocaine, etc.)

Adapted from E.S. Roach, et al. Pediatric Stroke and Cerebrovascular Disorders, Third Edition. Demos Medical. New York, 2011, 364 pp.

Back to Stroke Algorithm

Stroke Algorithm

DCMC Evidence-Based Outcomes Center

Back to Stroke Algorithm

Labs

	Initial Labs (send STAT)	Secondary Labs
Thrombotic or Hemorrhagic Stroke	Complete metabolic panel CBC w/ platelet count and peripheral smear PT (prothrombin time) aPTT (activated partial thromboplastin time) Fibrinogen Urinalysis Quantitative d-dimer BHCG in menarchal females Hgb electrophoresis for individuals at risk for hemoglobinopathy (if status unknown) Type and cross if anticipate exchange transfusion or IV tPA	Thrombin time (as deemed necessary) POC Glucose EKG (For unexplained Hemorrhagic Stroke - Discuss with Consulting Hematologist) Clotting factor Levels • von Willebrand studies • Platelet function screen <u>Metabolic:</u> when clinically suspect inborn error of metabolism as cause of infarction Lactic acid- plasma (CSF as suspected) Mitochondrial disease evaluation Autoimmune disease screen: when clinically suspect autoimmune disorder, but discuss with Rheumatology • ESR, CRP, C3, C4, CH50, ANA • <u>Infection:</u> • Varicella titer (varicella exposure may have been up to 12 months prior to ischemic infarct) • Drug Screen in at risk individuals
	Initial Labs (send STAT)	**Secondary Labs**
Ischemic Stroke	Complete metabolic panel CBC w/ platelet count and peripheral smear PT (prothrombin time) aPTT (activated partial thromboplastin time) Fibrinogen Urinalysis Quantitative d-dimer BHCG in menarcheal females Hgb electrophoresis for individuals at risk for hemoglobinopathy (if status unknown) Type and cross if anticipate exchange transfusion or IV tPA	(*Discuss with Consulting Hematologist*) Factor V Leiden Prothrombin 20210 Homocysteine Anti-Phospholipid Antibody Studies Panel StaClot LA Anticardiolipin Antibodies dRVVT (dilute Russell's Viper Venom Time) β2-Glycoprotein 1 Antibodies Protein C Activity Protein S Activity Anti-Thrombin Hemoglobin electrophoresis (in at risk individuals) Lipid panel Lipoprotein a Drug Screen in at risk individuals

Stroke Algorithm

DCMC Evidence-Based Outcomes Center

Table 2: Potential Stroke Mimics in Children

Complicated migraine
Post-ictal deficit
Focal ictal deficit
Acute disseminated encephalomyelitis (ADEM)
Encephalitis (e.g. herpes simplex, autoimmune encephalitis)
Cerebral abscess
Brain tumor
Labyrinthitis
Paraneoplastic disorder
Somatoform disorder

Table 3: Supportive Treatment

1. Maintain adequate oxygenation (SaO2 >95%)
2. Maintain normal glycemia
3. Avoid hyperthermia: Goal temp < 37.5C
4. Avoid negative fluid deficit as best as can be tolerated by patient's underlying medical condition
5. Suppress seizures: Consider cEEG monitoring in neonates or in pt w/altered consciousness
6. Monitor for increased ICP, herniation and aspiration
    - o PICU admission is essential for large MCA or hemispheric infarcts, posterior fossa infarction (cerebellum or brainstem), or significant subcortical infarct with risk for aspiration
7. Maintain cerebral perfusion
    - o Maintaining MAP no lower than 50%ile age norms, and no higher than 95%ile for age or 20 mm Hg above the pts. usual MAP
8. Brain edema and increased intracranial pressure
    - o Maintain cerebral perfusion by maintaining MAP
    - o Minimize free water administration by using normotonic fluids
    - o Consider hyperventilation to pCO2 of 35-40
        - ▪ Avoid more severe hypocarbia because that decreases cerebral blood flow
    - o Mannitol and hypertonic saline may be used for temporary emergency treatment of increased ICP; Target Na>135
    - o Consider emergency decompression of large MCA/ICA infarct or posterior fossa infarct if patient continues to deteriorate
9. Strong consideration on NPO for patients for first 24 hours, depending on age & clinical condition(s)
10. All patients with acute neurologic deficits should be admitted to the PICU with q1 hour neuro checks, for at least the first 24hours

Back to Stroke Algorithm

Table 4: History and Symptoms

- Family History – Coagulation Disorder
- Recent trauma, neck pain
- No history of moyamoya disease or brain tumor
- No history of seizures with Todd's paralysis (first time seizure is not a contraindication)
- No signs of meningitis or endocarditis
- Past medical history - Cardiac, rheumatologic, coagulation disorder
- Review Risk Factors for Pediatric Stroke

Stroke Algorithm

DCMC Evidence-Based Outcomes Center

Initial Treatment Guidelines:

Initial Treatment of Arterial Ischemic Stroke:

- **Sickle cell disease:** IV hydration, acute correction of anemia or exchange transfuse per hematology. See link for sickle cell stroke management protocol.

- **Anticoagulation with low molecular weight heparin, unfractionated heparin, warfarin**

  - Anticoagulate with heparin when there is a high risk of recurrent embolism (e.g. high embolism risk due to congenital heart disease)
  - Usually avoid anticoagulation with very large infarctions or infarction with hemorrhagic conversion.
  - Consider transient anticoagulation if stroke etiology is unknown pending elimination of embolism and serious coagulopathy
  - Anticoagulate patients with CVST (but not individuals with isolated cortical vein thrombosis)
  - Anticoagulation is no longer considered appropriate for arterial dissection (use aspirin now)

- **Aspirin and other antiplatelet agents**

  - Limited data in children, but more experience with aspirin than with other agents
  - Aspirin 3-5 mg/Kg/day will alter platelet adhesion assays.
  - Aspirin is now recommended for arterial dissection
  - Consider aspirin for intracranial vasculopathy or for idiopathic stroke.

Management of Cerebral Venous Sinus Thrombosis

- Reimage in response to clinical deterioration (rule out clot propagation, hemorrhagic conversion)

- Most acute CSVT patients (both neonates and older children) should be anticoagulated
  - Benefit even with secondary hemorrhage (unless large hemorrhage)
  - Do not anticoagulate patients with small medullary venous infarcts
  - Discuss exceptions with stroke neurologists and hematologists
  - In particular discuss management of CSVT in the setting of acute trauma
  - Treatment: UFH or LMWH initially
  - Treatment longer term: LMWH or warfarin for six months
  - If anticoagulation deferred because of large cerebral infarct or large hemorrhagic conversion, repeat imaging in 3-5 days; consider anticoagulation if thrombus extends

- Increased intracranial pressure (ICP) is a common complication, with pain and risk of blindness

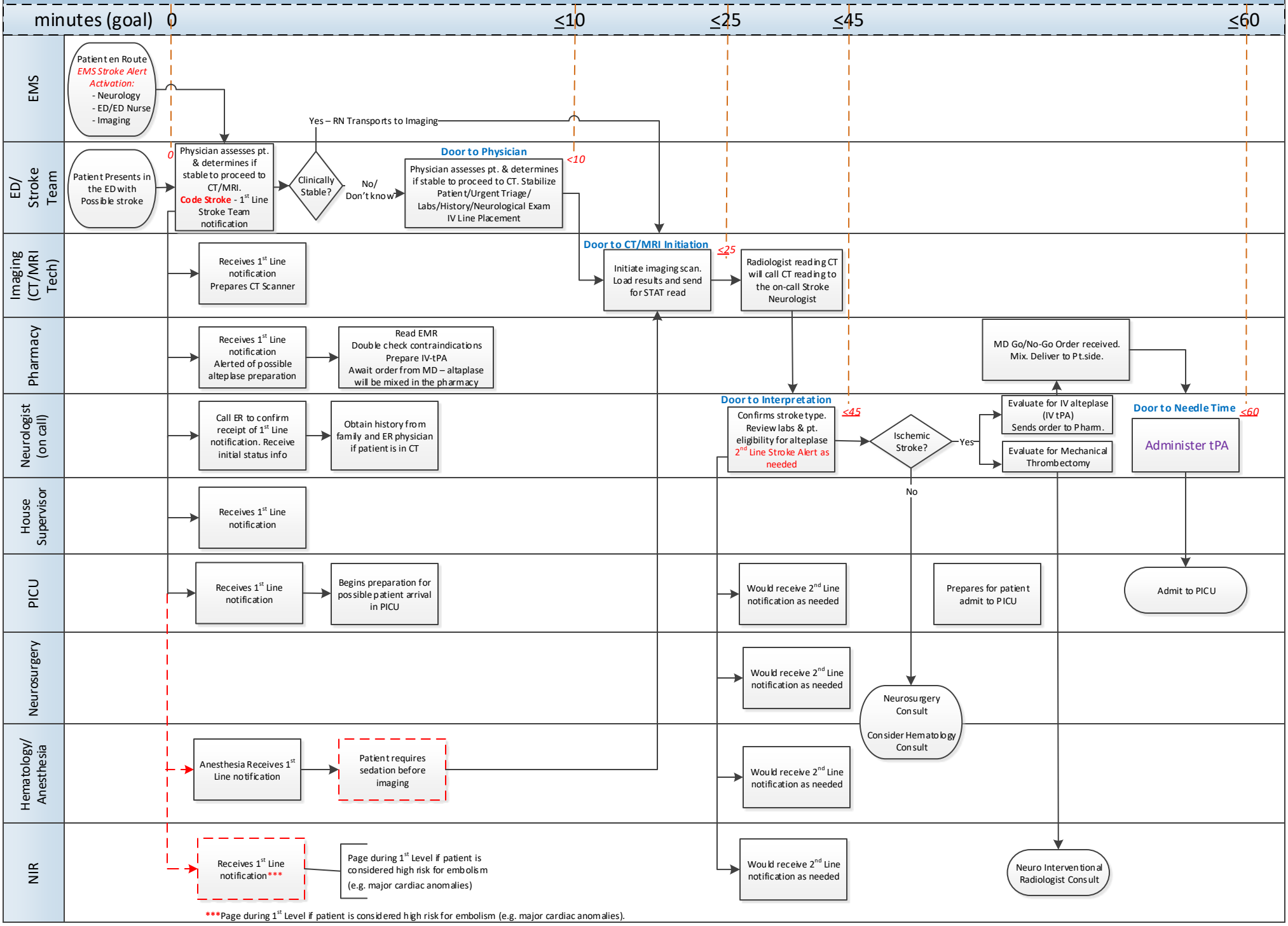
  - Ophthalmology consultation to document disc Friesen scale, acuity, and visual fields
  - Consider acetazolamide [add dosing] and then furosemide
  - Optic nerve sheath fenestration for progressive visual loss

Management of Primary Hemorrhagic Stroke

  - Brain CT scan is acceptable if strongly suspect intracranial hemorrhage. Otherwise, use MRI protocol as described earlier.
  - Manage as per neurosurgery recommendations
  - Consult hematology for patients with known or suspected bleeding disorders
  - There are no clear guidelines for the management of intracerebral hemorrhage in children without bleeding disorders
  - Basic homeostasis measures are similar to those for arterial ischemic stroke.
    - If hemorrhage is result of hemorrhagic conversion of arterial or venous infarction, manage as arterial ischemic stroke or cerebral sinovenous thrombosis
  - Prevent seizures and treat seizures aggressively
  - Primary ICH or SAH should prompt an early evaluation for a cerebrovascular cause or an underlying coagulopathy
  - The aneurysm causing a subarachnoid hemorrhage should be identified quickly to assist early intervention and reduce risk of early re-hemorrhage
  - Large (i.e. thick) subarachnoid hemorrhages have increased risk of vasospasm

Stroke Protocol (IV tPA)

The 'pit-crew' model for door to needle times (DTN) in Pediatric Stroke



***Page during 1st Level if patient is considered high risk for embolism (e.g. major cardiac anomalies).

Last Updated 8.27.2021

Stroke Algorithm

DCMC Evidence-Based Outcomes Center

Back to Stroke Algorithm

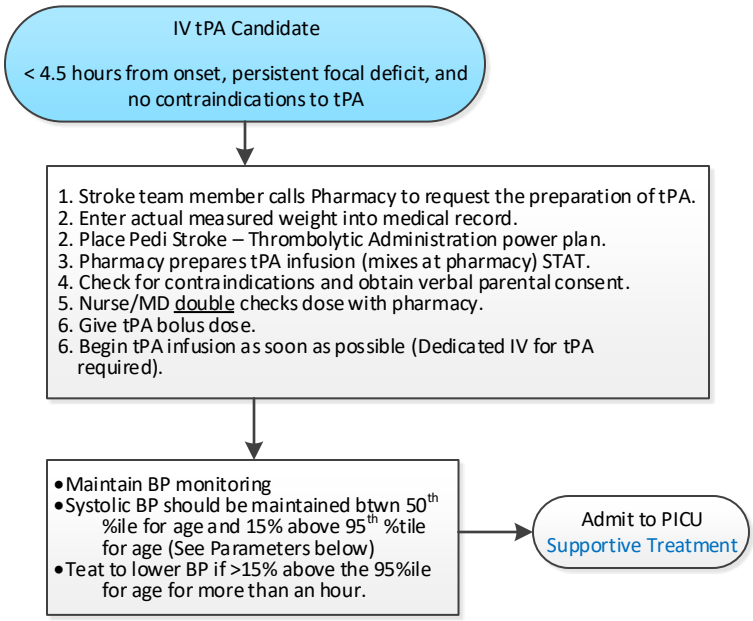
IV tPA Treatment Protocol

Systolic Blood Pressure Parameters - female

Age	50%	95%	> 15% above 95%	> 20% above 95%
1—4 years	90	111	128	133
5 years	94	113	130	136
6-10 years	96	121	139	145
11—18 years	105	131	151	157
> 18 years	110	140	161	168

Systolic Blood Pressure Parameters - male

Age	50%	95%	> 15% above 95%	> 20% above 95%
1—4 years	90	112	129	134
5 years	95	113	130	136
6-10 years	96	121	139	145
11—18 years	105	140	161	168
> 18 years	110	140	161	168



Post tPA Care

- All patients with acute neurologic deficits should be admitted to the PICU with q 1 hour neuro checks, for at least the first 24 hours
- Blood pressure checks
- Consult neurosurgery if signs of elevated ICP or CT reveals bleed
- HOB Flat
- NPO x 24 hours after tPA
- Labs as indicated by neurologist
- No arterial punctures, invasive procedures or anti-coagulants for 24 hours
- Maintain normothermia
- Maintain euglycemia

Consult/Referals:

- Case Management/Discharge planner
- Physiotherapy/Occupational Therapy/Speech Language Pathology
- Rehab Eval (Inpatient Rehab)