

Suspected Acute Stroke Executive Summary

Physician Owners: Dr. Geetanjali Rathore

PRIMARY OBJECTIVE

Early identification of acute focal neurological deficits and/or altered mental status followed by immediate rapid MRI brain imaging and radiologist interpretation for timely intervention in confirmed stroke cases.

RECOMMENDATIONS

Inclusion Criteria

- Children \geq 1 month

Exclusion Criteria:

- Children < 1 month of age

Presentation:

- Children who present with focal neurological deficits and/or a sudden unexplained change in mental status who were last seen normal < 24 hours ago AND whose symptoms have not completely resolved should be started on the suspected acute stroke pathway.
- Children with focal neurological deficits and/or a sudden unexplained change in mental status who were last seen normal > 24 hours ago should be managed off pathway as having subacute stroke.
- Additionally, children with focal neurological deficits and/or a sudden unexplained change in mental status who were last seen normal < 24 hours ago, but whose symptoms have completely resolved should be managed off pathway as having a transient ischemic attack (TIA).

Assessment:

- Assess for acute stroke. Risk factors for pediatric stroke include:
 - o Sickle cell disease
 - o Congenital or acquired heart disease
 - o Head and neck infections
 - o Systemic conditions , such as inflammatory bowel disease and autoimmune disorders
 - o Head trauma
- To activate the stroke team:
 - o Dial 0 to call operator & instruct to activate the “stroke team” (page includes MRI, pharmacy & on-call neurologist); provide patient name, MRN, room number, & extension # of RN caring for patient.
- Provider (ED or PICU), conduct Pediatric National Institutes of Health Stroke Scale (PedNIHSS). If imaging is immediately available, it is acceptable to complete the stroke scale after imaging is complete.

Clinical Management:

• **STAT Testing:**

- o MRI brain without contrast (“**MR Stroke Brain wo**” in Epic)
 - The MRI screening questionnaire must be completed in Epic before patients can enter the MRI room.
 - Brain imaging should occur ASAP after a stroke.
 - If imaging is available it should not be delayed in favor of labs, ECG, other testing, or establishing intravascular access (IV access not needed prior to MR).
 - If MRI will not be available within approximately one hour of placing the MRI order, or patient has contraindications to MRI, clinicians should instead consider CT head without contrast.
 - Staff should review Policy PTCR74h transporting/transferring a patient within the hospital and ensure patient is ready to transport to radiology as soon as imaging staff are available to begin exam.

Suspected Acute Stroke Executive Summary

- RN will need to accompany patient to radiology for imaging; especially if any sedation is needed.
 - o Labs: PT, PTT, INR, ESR, CRP, & EPOC panel which includes; blood gases, Hct, Hgb, NA, K, Ionized Ca, Cl, Glu, Lactate, Creat
 - o 12-lead ECG
- **Additional Supportive Care:**
 - o Establish intravascular access (if not already in place)
 - Patients that can't be discontinued from IV infusions may need extension tubing added prior to imaging
 - o Head of bed flat
 - o Keep blood pressure within normal limits for age
 - o Vital signs and neuro checks every 15 minutes
 - o Keep child NPO
 - o Ensure weight in Kg and time patient was last seen normal is documented in EMR
 - o Normal saline (don't give dextrose) if considering fluids
 - o Review tissue plasminogen activator (tPA) contraindications and eligibility for endovascular therapy while waiting for imaging results
- **MRI Brain "Stroke Protocol" and Imaging Notes:**
 - o In general, head CT does not require patient sedation, but the sensitivity of this method to detect arterial ischemic stroke (AIS) is low.² A study from a large tertiary children's medical center in Australia found that ischemic stroke was not visualized on head CT in 62 of 74 (84%) of children with this condition; all of these children had their stroke confirmed by MRI of the brain.³
 - o Children's Hospital and Medical Center's MRI Brain "Stroke Protocol" was developed in accordance with commonly reported protocols for stroke.^{6, 7, 8} This protocol may serve as a surrogate to head CT when acute stroke is suspected. In cooperative patients, the MRI brain "Stroke Protocol" will take less than 10 minutes and is performed without sedation. MRI of the brain without contrast is the preferred first line imaging choice when acute stroke is suspected.
 - o The sequences acquired during the "Stroke Protocol" include:
 - Axial DWI - for seeing infarct
 - Axial FLAIR - signal abnormality, general features of brain parenchyma
 - Axial FFE (GRE) - for hemorrhage (or calcification)
 - Sagittal T1 Single Shot - subacute hemorrhage, general features of brain parenchyma
 - » Children with a pacemaker or other devices like a vagal nerve stimulator should have noncontrast head CT first. The necessary steps to image these children with MR take far longer than 1 hour.
 - » Children with a cardiac pacemaker will need special evaluation and monitoring if the pacer is MR compatible.
 - » Some devices like vagal nerve stimulators cannot have a DWI sequence and are limited to their own unique protocol.
 - o Ventricle size as well as anatomical abnormalities; including stroke, hemorrhage, ventriculomegaly, mass, brain edema and other conditions can be identified when the MRI brain "Stroke Protocol" is ordered.
 - o Contrast enhanced sequences, such as contrast enhanced MRA, have been omitted for time saving purposes and to avoid delays secondary to IV placement which would be needed for contrast.
 - o Additional imaging of the brain and/or vascular anatomy may at times be necessary and should be considered by clinicians on a case-by-case basis after the initial brain imaging report is received from radiologist, taking into account patient condition and availability of resources.

• Imaging Results

- o The radiologist will contact ordering clinician with imaging results
- o When intracranial hemorrhage is present;
 - **Admit to PICU**
 - Manage as hemorrhagic stroke
 - Consider neurosurgical consult
- o When ischemic stroke is present:
 - **Admit to PICU**
 - Manage as ischemic stroke
 - Follow tPA treatment protocol (if child is eligible)
 - Aspirin 5 mg/kg (max 81 mg) every 24 hours
 - » Start aspirin 24-48 hours after stroke onset if tPA is given
 - » Start aspirin immediately if tPA is not given
- o When intracranial hemorrhage or ischemic stroke are not present, patient care should be managed off pathway

RATIONALE (SAFETY, QUALITY, COST, DELIVERY, ENGAGEMENT, & SATISFACTION)

- **Safety:** Better access to MRI and faster brain imaging sequences will decrease the need for head imaging with CT, which will decrease patient's lifetime exposure to radiation.
- **Quality:** Shall be improved by decreasing the amount of time between acute stroke recognition and intervention.
- **Cost:** Early identification of acute stroke will decrease both the short and long term costs associated with caring for these patients.
- **Delivery:** Shall be improved by giving suspected stroke cases prioritization over non-acute conditions.
- **Engagement:** Is created and supported by the involvement of a multidisciplinary team in the development and maintenance of the pathway.
- **Patient/Family Satisfaction:** Early identification will lead to early intervention. Early intervention will decrease the impairments of patients with stroke which will improve both patient and family satisfaction.

IMPLEMENTATION ITEMS

- Suspected acute stroke order set
- tPA order set
- Suspected acute stroke paging system
- Rapid MRI brain stroke protocol
- tPA infusion protocol

METRICS PLAN

1. Monitor time from patient arrival in ED to imaging.
2. Monitor imaging completion time to report time.
3. Monitor number of initial head CTs and Brain MRIs performed on patients suspected of having an acute stroke.
4. Monitor time from stroke alert being called to time of imaging.

SUPPORTING DOCUMENTS (PATHWAY, INCLUSION/EXCLUSION CRITERIA, DEFINITIONS, ALGORITHM)

- Suspected Acute Stroke (Algorithm 1)
- tPA Treatment Protocol (Algorithm 2)
- tPA Contraindications (Appendix A)
- Blood Pressure Normal Limits for Age Parameters (Appendix B)
- Pediatric National Institutes of Health Stroke Scale (Ped NIHSS)(Appendix C)
- Policy PTCR74h Transporting/Transferring a Patient within the Hospital

TEAM MEMBERS

Dr. Geetanjali Rathore (Neurology), Dr. Stephen Dolter (Hospitalist Service), Dr. Susan Kelly (Emergency Department), Dr. Andria Powers (Radiology), Dr. Travis Kruse (Radiology), Cheri Rubio RN (Performance Improvement), Jill Bechaz & Mary Jo White (Pharmacy), Dr. Edward Truemper (Intensivist Service), Amber Marquiss (IT), Katie Kendrick RN (IT)

REFERENCES

1. Rivkin MJ, Bernard TJ, Dowling MM, Amlie-Lefond C. Guidelines for urgent management of stroke in children. *Pediatric Neurology* 2016;56:8-17. doi:10.1016/j.pediatrneurol.2016.01.016
2. Jordan LC, Hillis AE. Challenges in the diagnosis and treatment of pediatric stroke. *Nature Reviews Neurology*. 2011;7(4):199-208. doi:10.1038/nrneurol.2011.23.
3. Srinivasan J, Miller SP, Phan TG, Mackay MT. Delayed recognition of initial stroke in children: need for increased awareness. *Pediatrics*. 2009; 124:e227–234. [PubMed: 19620205]
4. Ladner TR, et.al. Pediatric acute stroke protocol in a children's hospital emergency department. *Stroke*. 2015;46:2328-2331, originally published July 2, 2015
5. DeLaroce, AM. et al. Pediatric stroke clinical pathway improves the time to diagnosis in an emergency department. *Pediatric Neurology*. Volume 65, 39-44.
6. Srinivasan A, Goyal M, Al azri F et.al. State-of-the-art imaging of acute stroke. *Radiographics*. 2006;26 Suppl 1 : S75-95 <http://pubs.rsna.org/doi/pdf/10.1148/rg.26si065501>
7. Nael, K et al. Six-minute magnetic resonance imaging protocol for evaluation of acute ischemic stroke. Pushing the boundaries. *Stroke*. 2014;45: 1985-1991.
8. Mirsky, D et al. Pathways for neuroimaging of childhood stroke. *Pediatric Neurology*. Volume 69, 11-23

Appendix A

Tissue Plasminogen Activator (tPA) Contraindications:¹

History

- > 4.5 hrs from last seen well
- Patients in whom time of symptom onset is unknown
- Stroke, major head trauma or intracranial surgery in the last 3 months
- History of prior intracranial hemorrhage, known arteriovenous malformation (AVM) or aneurysm
- Major surgery or parenchymal biopsy within 10 days
- GI or GU bleeding within 21 days
- Patient with neoplasm/malignancy or within one month of completion of treatment for cancer
- Patients with underlying significant bleeding disorder. Patients with mild platelet dysfunction, mild Von Willebrand disease or other mild bleeding disorders are NOT excluded
- Previously diagnosed primary angitis of the central nervous system or secondary arteritis

Patient Factors

- Patient who would decline a blood transfusion if indicated
- Clinical presentation consistent with acute myocardial infarction (MI) or post MI pericarditis that requires evaluation by cardiology before treatment
- Arterial puncture at noncompressible site or lumbar puncture within last 7 days. Patients who have had cardiac cath via a compressible artery are NOT excluded

Etiology

- Stroke due to subacute bacterial endocarditis (SBE), sickle cell disease, meningitis, embolism (bone marrow, air or fat), or Moyamoya disease

Exam

- Persistent systolic blood pressure > 15% above the 95th percentile for age while sitting or supine
- Mild deficit (PedNIHSS < 6) at start of tPA infusion
- Severe deficit suggesting very large territory stroke pre-tPA
- PedNIHSS > 25, regardless of infarct volume seen on neuroimaging

Imaging

- Symptoms suggestive of subarachnoid hemorrhage even if CT or MRI of head are normal
- CT with hypodensity/sulcal effacement > 33% of middle cerebral artery (MCA) territory or Alberta Stroke Program Early CT Scoring (ASPECTS) ≤ 7
- Intracranial cervicocephalic arterial dissection

Lab Data

- Glucose < 50 mg/dL (2.78 mmol/L) or > 400 mg/dL (22 mmol/L)
- Bleeding diathesis including Platelets < 100,000, PT > 15 sec, INR >1.4 or elevated PTT > upper limits of the normal range

Appendix B

Blood Pressure Normal Limits for Age Parameters:

Notify provider for blood pressure outside of normal range

Age	Blood Pressure (mm Hg)
0-3 mo	65-85/45-55
3-6 mo	70-90/50-65
6-12 mo	80-100/55-65
1-3 yr	90-105/55-70
3-6 yr	95-110/60-75
6-12 yr	100-120/60-75
12+ yr	110-135/65-85

Appendix C

Pediatric NIH Stroke Scale (PedNIHSS)	
Item # and Instructions	Scale Definition and Scoring Guide
<p>1a. Level of Consciousness: the investigator must choose a response, even if a full evaluation is prevented by such obstacles as an endotracheal tube, language barrier, orotracheal trauma/bandages. A 3 is scored only if the patient makes no movement (other than reflexive posturing) in response to noxious stimulation.</p>	<p>0 = Alert; keenly responsive.</p> <p>1 = Not alert, but arousable by minor stimulation to obey, answer, or respond.</p> <p>2 = Not alert, requires repeated stimulation to attend, or is obtunded and requires strong or painful stimulation to make movements (not stereotyped).</p> <p>3 = Responds only with reflex motor or autonomic effects or totally unresponsive, flaccid, areflexic.</p>
<p>1b. LOC Questions: The patient is asked the month and his/her age. The answer must be correct - there is no partial credit for being close. Aphasic and stuporous patients who do not comprehend the questions will score 2. Patients unable to speak because of endotracheal intubation, orotracheal trauma, severe dysarthria from any cause, language barrier or any other problem not secondary to aphasia are given a 1. It is important that only the initial answer be graded and that the examiner not "help" the patient with verbal or non-verbal cues. Modified for children, age 2 years and up. A familiar family member must be present for this item: Ask the child "how old are you?" Or "How many years old are you?" for question number one. Give credit if the child states the correct age, or shows the correct number of fingers for his/her age. For the second question, ask the child "where is XX?", XX referring to the name of the parent or other familiar family member present. Use the name for that person which the child typically uses, e.g. "mommy". Give credit if the child correctly points to or gazes purposefully in the direction of the family member.</p>	<p>0 = Answers both questions correctly.</p> <p>1 = Answers one question correctly.</p> <p>2 = Answers neither question correctly.</p>

Suspected Acute Stroke

Executive Summary

Appendix C

<p>1c. LOC Commands: The patient is asked to open and close the eyes and then to grip and release the non-paretic hand. For children one may substitute the command to grip the hand with the command “show me your nose” or “touch your nose”. Substitute another one step command if the hands cannot be used. Credit is given if an unequivocal attempt is made but not completed due to weakness. If the patient does not respond to command, the task should be demonstrated to them (pantomime) and score the result (i.e., follows none, one or two commands). Patients with trauma, amputation, or other physical impediments should be given suitable one-step commands. Only the first attempt is scored.</p>	<p>0 = Performs both tasks correctly 1 = Performs one task correctly 2 = Performs neither task correctly</p>
<p>2. Best Gaze: Only horizontal eye movements will be tested. Voluntary or reflexive (oculocephalic) eye movements will be scored but caloric testing is not done. If the patient has a conjugate deviation of the eyes that can be overcome by voluntary or reflexive activity, the score will be 1. If a patient has an isolated peripheral nerve paresis (CN III, IV or VI) score a 1. Gaze is testable in all aphasic patients. Patients with ocular trauma, bandages, pre-existing blindness or other disorder of visual acuity or fields should be tested with reflexive movements and a choice made by the investigator. Establishing eye contact and then moving about the patient from side to side will occasionally clarify the presence of a partial gaze palsy.</p>	<p>0 = Normal 1 = Partial gaze palsy. This score is given when gaze is abnormal in one or both eyes, but where forced deviation or total gaze paresis are not present. 2 = Forced deviation, or total gaze paresis not overcome by the oculocephalic maneuver.</p>
<p>3. Visual: Visual fields (upper and lower quadrants) are tested by confrontation, using finger counting (for children > 6 years) or visual threat (for children age 2 to 6 years) as appropriate. Patient must be encouraged, but if they look at the side of the moving fingers appropriately, this can be scored as normal. If there is unilateral blindness or enucleation, visual fields in the remaining eye are scored. Score 1 only if a clear-cut asymmetry, including quadrantanopia is found. If patient is blind from any cause score 3. Double simultaneous stimulation is performed at this point. If there is extinction patient receives a 1 and the results are used to answer question 11.</p>	<p>0 = No visual loss 1 = Partial hemianopia 2 = Complete hemianopia 3 = Bilateral hemianopia (blind including cortical blindness)</p>
<p>4. Facial Palsy: Ask, or use pantomime to encourage the patient to show teeth or raise eyebrows and close eyes. Score symmetry of grimace in response to noxious stimuli in the poorly responsive or non-comprehending patient. If facial trauma/bandages, orotracheal tube, tape or other physical barrier obscures the face, these should be removed to the extent possible.</p>	<p>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 (absence of facial movement in the upper and lower face)</p>

Suspected Acute Stroke Executive Summary

Appendix C

5 & 6. Motor Arm and Leg: The limb is placed in the appropriate position: extend the arms (palms down) 90 degrees (if sitting) or 45 degrees (if supine) and the leg 30 degrees (always tested supine). Drift is scored if the arm falls before 10 seconds or the leg before 5 seconds. **For children too immature to follow precise directions or uncooperative for any reason, power in each limb should be graded by observation of spontaneous or elicited movement according to the same grading scheme, excluding the time limits.** The aphasic patient is encouraged using urgency in the voice and pantomime but not noxious stimulation. Each limb is tested in turn, beginning with the non-paretic arm. Only in the case of amputation or joint fusion at the shoulder or hip, **or immobilization by an IV board**, may the score be "9" and the examiner must clearly write the explanation for scoring as a "9". Score each limb separately.

5a. Left Arm

5b. Right Arm

- 0 = No drift, limb holds 90 (or 45) degrees for full 10 seconds.
- 1 = Drift, Limb holds 90 (or 45) degrees, but drifts down before full 10 seconds; does not hit bed or other support.
- 2 = Some effort against gravity, limb cannot get to or maintain (if cued) 90 (or 45) degrees, drifts down to bed, but has some effort against gravity.
- 3 = No effort against gravity, limb falls.
- 4 = No movement
- 9 = Amputation, joint fusion explain:

6a. Left Leg

6b. Right Leg

- 0 = No drift, leg holds 30 degrees position for full 5 seconds. 1 = Drift, leg falls by the end of the 5 second period but does not hit bed.
- 2 = Some effort against gravity; leg falls to bed by 5 seconds, but has some effort against gravity.
- 3 = No effort against gravity, leg falls to bed immediately.
- 4 = No movement
- 9 = Amputation, joint fusion explain:

Suspected Acute Stroke Executive Summary

Appendix C

<p>7. Limb Ataxia: This item is aimed at finding evidence of a unilateral cerebellar lesion. Test with eyes open. In case of visual defect, insure testing is done in intact visual field. The finger-nose-finger and heel-shin tests are performed on both sides, and ataxia is scored only if present out of proportion to weakness. In children, substitute this task with reaching for a toy for the upper extremity, and kicking a toy or the examiner's hand, in children too young (< 5 years) or otherwise uncooperative for the standard exam item. Ataxia is absent in the patient who cannot understand or is paralyzed. Only in the case of amputation or joint fusion may the item be scored "9", and the examiner must clearly write the explanation for not scoring. In case of blindness test by touching nose from extended arm position.</p>	<p>0 = Absent 1 = Present in one limb 2 = Present in two limbs</p>
<p>8. Sensory: Sensation or grimace to pin prick when tested, or withdrawal from noxious stimulus in the obtunded or aphasic patient. For children too young or otherwise uncooperative for reporting gradations of sensory loss, observe for any behavioral response to pin prick, and score it according to the same scoring scheme as a "normal" response, "mildly diminished" or "severely diminished" response. Only sensory loss attributed to stroke is scored as abnormal and the examiner should test as many body areas [arms (not hands), legs, trunk, face] as needed to accurately check for hemisensory loss. A score of 2, "severe or total," should only be given when a severe or total loss of sensation can be clearly demonstrated. Stuporous and aphasic patients will therefore probably score 1 or 0.</p>	<p>0 = Normal; no sensory loss. 1 = Mild to moderate sensory loss; patient feels pinprick is less sharp or is dull on the affected side; or there is a loss of superficial pain with pinprick but patient is aware he/she is being touched. 2 = Severe to total sensory loss; patient is not aware of being touched in the face, arm, and leg.</p>

Suspected Acute Stroke

Executive Summary

Appendix C

<p>9. Best Language: A great deal of information about comprehension will be obtained during the preceding sections of the examination. For children age 6 years and up with normal language development before onset of stroke: The patient is asked to describe what is happening in the attached picture, to name the items on the attached naming sheet, to repeat words from the attached list, and to read from the attached list of sentences (Table S1; Fig S1, S2, S3). Comprehension is judged from responses here as well as to all of the commands in the preceding general neurological exam. If visual loss interferes with the tests, ask the patient to identify objects placed in the hand, repeat, and produce speech. The intubated patient should be asked to write. The patient in coma (question 1a=3) will arbitrarily score 3 on this item. The examiner must choose a score in the patient with stupor or limited cooperation but a score of 3 should be used only if the patient is mute and follows no one step commands. For children age 2 yrs to 6 yrs (or older children with premorbid language skills < 6 yr level), score this item based on observations of language comprehension and speech during the examination. The patient with brain stem stroke who has bilateral loss of sensation is scored 2. If the patient does not respond and is quadriplegic score 2. Patients in coma (item 1a=3) are arbitrarily given a 2 on this item.</p>	<p>0 = No aphasia, normal</p> <p>1 = Mild to moderate aphasia; some obvious loss of fluency or facility of comprehension, without significant limitation on ideas expressed or form of expression. Reduction of speech and/or comprehension, however, makes conversation about provided material difficult or impossible. For example in conversation about provided materials examiner can identify picture or naming card from patient's response.</p> <p>2 = Severe aphasia; all communication is through fragmentary expression; great need for inference, questioning, and guessing by the listener. Range of information that can be exchanged is limited; listener carries burden of communication. Examiner cannot identify materials provided from patient response.</p> <p>3 = Mute, global aphasia; no usable speech or auditory comprehension.</p>
<p>10. Dysarthria: If patient is thought to be normal an adequate sample of speech must be obtained by asking patient to read or repeat words from the attached list. If the patient has severe aphasia, the clarity of articulation of spontaneous speech can be rated. Only if the patient is intubated or has other physical barrier to producing speech, may the item be scored "9", and the examiner must clearly write an explanation for not scoring. Do not tell the patient why he/she is being tested.</p>	<p>0 = Normal</p> <p>1 = Mild to moderate; patient slurs at least some words and, at worst, can be understood with some difficulty.</p> <p>2 = Severe; patient's speech is so slurred as to be unintelligible in the absence of or out of proportion to any dysphasia, or is mute/anarthric.</p> <p>9 = Intubated or other physical barrier, explain:</p>
<p>11. Extinction and Inattention (formerly Neglect): Sufficient information to identify neglect may be obtained during the prior testing. If the patient has a severe visual loss preventing visual double simultaneous stimulation, and the cutaneous stimuli are normal, the score is normal. If the patient has aphasia but does appear to attend to both sides, the score is normal. The presence of visual spatial neglect or anosagnosia may also be taken as evidence of abnormality. Since the abnormality is scored only if present, the item is never untestable.</p>	<p>0 = No abnormality.</p> <p>1 = Visual, tactile, auditory, spatial, or personal inattention or extinction to bilateral simultaneous stimulation in one of the sensory modalities.</p> <p>2 = Profound hemi-inattention or hemi-inattention to more than one modality. Does not recognize own hand or orients to only one side of space.</p>

Suspected Acute Stroke Executive Summary

Appendix C

Repetition	Each of 4 word-repetition tasks is presented: a. Stop b. Stop and go c. If it rains we play inside d. The President lives in Washington
Reading	Each of 3 items is presented for the child to read in Fig 1. Adjust expectations according to child's age/school level
Naming	Pictures are presented and of a clock, pencil, skateboard, shirt, baseball, bicycle (Fig 2).
Fluency and word finding	The picture (Fig 3) is presented and the child is asked to describe what he/she sees.

Stop

See the dog run

Little children like to play outdoors

Fig. S1. Reading items for PedNIHSS

Suspected Acute Stroke Executive Summary

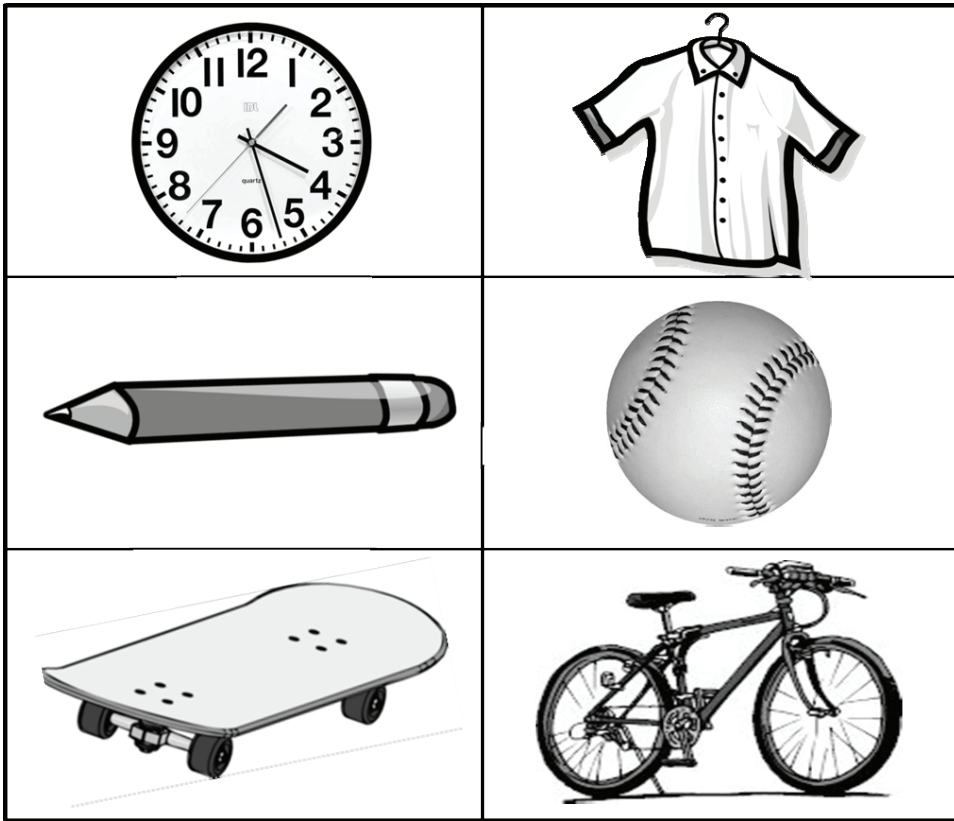


Fig. S2. Pictures to test naming for Item 9 Best Languages of PedNIHSS

Suspected Acute Stroke Executive Summary

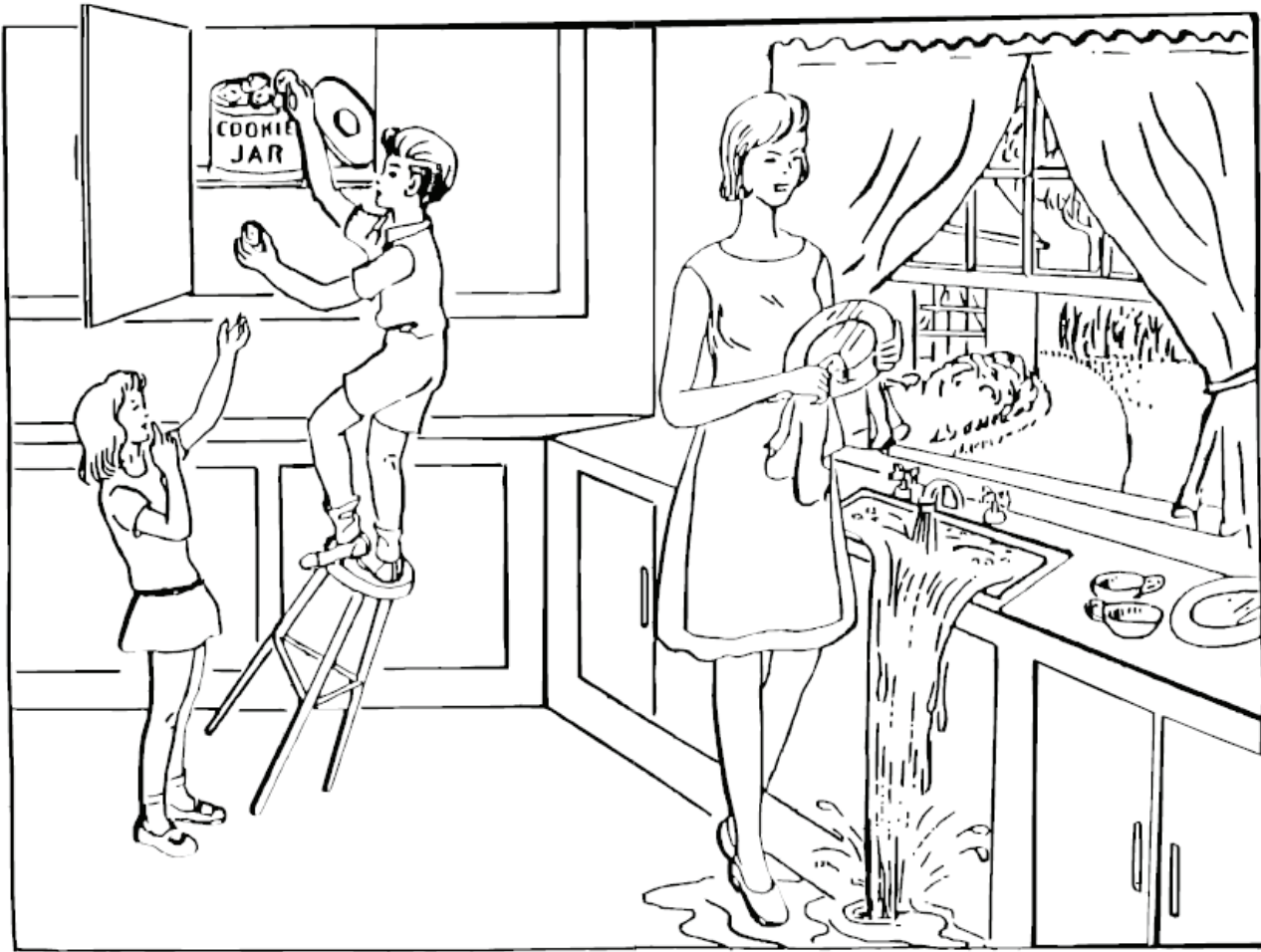


Fig. S3. Pictures to test story-telling for Item 9 Best Languages of PedNIHSS