Sudden Neurologic Deterioration

Emergency Department

Center for Clinical Excellence

Nationwide Children's — When your child needs a hospital, everything matters.

Diagnosis & Definition

Signs or Symptoms of Stroke

Differential Diagnosis

SND Alert & SND Watcher Evaluation

Patient with acute neurologic signs or symptoms

Exclusion Criteria:
- Trauma, including NAT
- Evidence of spinal cord or peripheral nerve etiology

Nurse performs **BE FAST**

Positive or concern? — No → **Off Pathway**: Treat condition according to standard of care

Yes

Neuro Huddle:
EM attending or fellow to bedside
Risk Factors for Stroke

Patients can be placed on this pathway at any time based on clinical concern

Findings concerning for SND? — No → **Off Pathway**: Treat condition according to standard of care

Yes

Any of the following?
- Current neurologic focal deficit
- GCS < 14
- PedNIHSS > 4

No → Utilize SND Watcher order set
- Upgrade to Alert if condition worsens

Yes → Utilize SND Alert order set

Do not delay neuroimaging for lab results or consultant evaluation

Impending herniation on imaging? — Yes → STAT Neurosurgery consult

No

Indicators of stroke on imaging? — Yes → Stroke Management

No

Please note that CT does not have high sensitivity for acute cytotoxic/ischemic injury especially within the first few hours

Team huddle to determine next steps

Admit? — No → Discharge when meeting criteria

Yes → **Admit to appropriate service**

Diagnosis & Definition

- Sudden neurologic deterioration (SND) is defined as new, undifferentiated neurological symptoms.
  - This also includes a history of focal deficits without current symptoms/exam findings.
  - Although duration of symptoms is important – symptoms present for >4 hours does not exclude patients from this pathway.

Return to SND Algorithm

BE FAST Nursing Triage Tool

B **Balance**
Loss of balance, headache or dizziness

E **Eyes**
Blurred Vision

F **Face**
One side of the face is drooping

A **Arms**
Arm or leg weakness

S **Speech**
Speech Difficulty

T **Timing**
What time did this start?

Return to SND Algorithm

Signs or Symptoms of Stroke

- Unilateral weakness
- Speech difficulty (aphasia or dysarthria)
- Vision loss or diplopia
- Ataxia
- Unilateral sensory change
- Vertigo
- New-onset focal seizure with atypical prolonged postictal paralysis

Return to SND Algorithm

Risk Factors for Pediatric Stroke

- **Cardiac**
  - Congenital heart disease with a shunting lesion
  - Mechanical valve or mechanical assist device
  - Arrhythmias
  - Heart failure
  - Endocarditis
- **Hematology & Coagulation**
  - Sickle cell disease
    - Have high suspicion for stroke in patients with history of abnormal transcranial dopplers or history of vasculopathy (e.g. Moyamoya disease)
  - Hypercoagulable condition including oral contraceptives with estrogen, recent treatment with L-Asparginase
  - Dehydration
- **Cerebral vasculopathy & Vasculitis**
  - Moyamoya disease or systemic large vessel vasculitis, such as Takayasu's
- **Metabolic**
  - Mitochondrial encephalopathy
- **Genetic**
  - Trisomy 21
  - Neurofibromatosis
  - Connective tissue disorders
  - PHACE(S) Syndrome:
    - Posterior fossa malformations
    - Hemangioma of the cervicofacial region
    - Arterial anomalies
    - Cardiac anomalies
    - Eye anomalies
    - Sternal or abdominal clefting or ectopia cordis
- **Head, neck or CNS infections**
  - Meningitis/encephalitis
  - Mastoiditis
  - Lemierre’s syndrome (septic thrombophlebitis of the internal jugular vein)
- **Trauma**
  - Recent minor head or neck trauma
  - Non-accidental trauma
- **Rheumatological disease**
  - Lupus
- **Medications**
  - Oral contraceptives with estrogen
  - L-Asparginase
  - IVIG
- **Oncologic**

Return to Algorithm

Glasgow Coma Scale

Behavior	Response	Score
Eyes	Spontaneously	4
	To speech	3
	To Pain	2
	No response	1
Verbal	Oriented to time, place and person	5
	Confused	4
	Inappropriate words	3
	Incomprehensible sounds	2
	No response	1
Motor	Obeys commands	6
	Moves to localized pain	5
	Flexion withdrawal from pain	4
	Abnormal flexion	3
	Abnormal extension	2
	No response	1
Total Score	Best Response	15
	Totally unresponsive	3

Return to SND Algorithm

Pediatric NIH Stroke Scale

Item# and Instructions	Scale Definition and Scoring Guide
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.	0 = Alert; keenly responsive. 1 = Not alert, but arousable by minor stimulation to obey, answer, or respond. 2 = Not alert, requires repeated stimulation to attend, or is obtunded and requires strong or painful stimulation to make movements (not stereotyped). 3 = Responds only with reflex motor or autonomic effects or totally unresponsive, flaccid, areflexic.
b. 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.*	0 = Answers both questions correctly. 1 = Answers one question correctly. 2 = Answers neither question correctly.
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.	0 = Performs both tasks correctly 1 = Performs one task correctly 2 = Performs neither task correctly
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, preexisting 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.	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.
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.	0 = No visual loss 1 = Partial hemianopia 2 = Complete hemianopia 3 = Bilateral hemianopia (blind including cortical blindness)
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.	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)
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 nonparetic arm. Only in the case of amputation or joint fusion at the shoulder or hap, *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:
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 fingernose-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.	0 = Absent 1 = Present in one limb 2 = Present in two limbs
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.	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.
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.*	0 = No aphasia, normal 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. 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. 3 = Mute, global aphasia; no usable speech or auditory comprehension.
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.	0 = Normal 1 = Mild to moderate; patient slurs at least some words and, at worst, can be understood with some difficulty. 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. 9 = Intubated or other physical barrier, explain:
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.	0 = No abnormality. 1 = Visual, tactile, auditory, spatial, or personal inattention or extinction to bilateral simultaneous stimulation in one of the sensory modalities. 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.

Return to SND Algorithm

Differential Diagnoses

Trauma	Vascular	Neoplastic
• Cerebral edema • Cerebral contusion • Intracranial hemorrhage • Extracranial hemorrhage	• Strokes • Intracerebral hemorrhage • Dural sinus thrombosis • Vascular anomalies/ malformation	• Brain tumor • Chemotherapy toxicities
Inflammatory/Infection	**Metabolic**	**Other**
• Meningitis • Encephalitis • Abscess • Acute cerebella ataxia • Cerebellitis • Demyelinating disease • Bell's Palsy	• Inborn errors of metabolism • Hepatic encephalopathy • Renal failure • Hypoglycemia	• Hydrocephalus • Idiopathic intracranial hypertension • Seizures/epilepsy • Migraine • Intoxication/drug toxicity • Functional neurological disorders

Return to SND Algorithm

SND Watcher & SND Alert Evaluation

	Watcher	Alert
Labs	POCT glucose, CBC w/ diff, CMP, urinalysis, UDS, Urine HCG (females >10yo), Ethanol (≥12yo)	POCT glucose, CBC w/ diff, CMP, urinalysis, UDS, Urine HCG (females >10yo), aPTT, PT, INR, Fibrinogen, Type & Screen, Ethanol (≥12yo)
	Sickle Cell patients: consider adding Hgb Electrophoresis	
Nursing Orders	Q1h neuro checks, EKG, Place IV	Q15min neuro checks, EKG, Place IV, supplemental O2
Consults	Page out to MRI technologists. Consider neurology consult.	Neurology consult (phone vs. in-person consult TBD by care team) with pages out to neuroradiology, MRI techs, neurosurgery, and critical care

Imaging (Watcher and Alert):
MR Head Short Stroke/Sudden Neurologic Deterioration

- If abnormal, reflex to MRA head and neck per Radiology
- If unable to obtain MRI (preferred modality), obtain CT Head **without** contrast and CTA Head & Neck **with** contrast
  - Please note that CT does not have high sensitivity for acute cytotoxic/ischemic injury especially within the first few hours

STAT MRI order will not be **automatically** scheduled without "***SND ED Team Activation" through ECC***. Activation of the ED SND Team by an ECC page will automatically schedule MRI, mobilize MRI team and notify neuroradiology. Neuroradiologist may reach out to the ordering provider or can be contacted at 2-9244 after SND Team initiated, but this is not required.

Return to SND Algorithm

Severity Assessment

- Pediatric NIH Stroke Scale
- Glasgow Coma Scale
- Sepsis and SND can often present similarly and congruently – being on one pathway does not preclude a patient from being on another
  - The primary provider will decide which process takes priority based on patient's clinical needs

Return to SND Algorithm

Assessment & Monitoring

Neuroprotective Care

- Isotonic IVF as clinically indicated
- NPO
- Maintain normothermia and normotension (see table below)
- Bed rest
- Head of bed flat except if concern for increased intracranial pressure (ICP), then elevate head of bed to 30 degrees
- Acetaminophen 15 mg/kg Rectal/IV/PO Q6H PRN temp >37.5°C
- Notify provider of any seizure-like activity

MRI monitoring

- Alerts are required to be accompanied by an RN
- Watchers may be accompanied by an RN depending on clinical need

Normal Blood Pressure by Age (mm Hg)

Age	Systolic BP	Diastolic BP	MAP (Mean Arterial Pressure)
Birth (12 hrs, <1000g)	39-59	16-36	28-42
Birth (12 hrs, 3kg)	60-76	31-45	48-57
Neonate (96 hours)	67-84	35-53	45-60
1-12 months	72-104	37-56	50-62
1-2 years	86-106	42-63	49-62
3-5 years	89-112	46-72	58-69
6-7 years	97-115	57-76	66-72
10-12 years	102-120	61-80	71-79
12-15 years	110-131	64-83	73-84

Adapted from:
Pediatric Advanced Life Support (PALS) Guidelines, 2015

Return to SND Algorithm

Stroke Management

Recommended Treatments

For patients with **stroke** – utilize stroke treatments found within SND order set for **ischemic stroke, hemorrhagic stroke** and **stroke in sickle cell disease.**

Patients with stroke require individualized management per Neurology recommendations.

- Ischemic stroke
  - Consider alteplase (tPA) within 4.5 hours
  - Thrombectomy for proximal large vessel occlusion
  - Antithrombotic therapy
    - Consider unfractionated heparin or LMW heparin (aka enoxaparin)
    - Consider aspirin

- Hemorrhagic stroke
  - Neurosurgery consult

- Stroke in sickle cell disease
  - Hematology consult
  - Consider simple vs. exchange transfusion

All other diagnoses should be treated using the standard of care in conjunction with appropriate consultation.

Return to SND Algorithm

Deterioration & Escalation of Care

Identification of Deterioration

- Declining mental status
- Worsening NIH Stroke Scale
- Status Epilepticus
- Provider or parental concern

Escalation of Care Protocol

- If Watcher – can upgrade to Alert
- Secure airway if necessary
- Include PICU in decision-making

Return to SND Algorithm

Admission Considerations

- Dependent on imaging/lab findings, consultant recommendations, and intact home support systems
- Being either an Alert or Watcher does not automatically require admission

Return to SND Algorithm

Discharge Criteria & Planning

- Discharge criteria:
  - Consultant recommendations completed (as indicated)
  - Stable vital signs
  - Appropriate home support system in place
- Close follow-up with PCP in 2-3 days
- Appropriate consultant follow-up as indicated, for example:
  - Neurology
  - First time seizure clinic
  - Neurosurgery

Return to SND Algorithm

Patient & Caregiver Education

- Education on:
  - BE FAST
  - Pediatric NIH Stroke Scale
  - SND PROVIDER EDUCATION

Return to SND Algorithm

Key References

- Rivkin MJ, Bernard TJ, Dowling MM, Amlie-Lefond C. Guidelines for Urgent Management of Stroke in Children [published correction appears in Pediatr Neurol. 2016 Nov;64:105. doi: 10.1016/j.pediatrneurol.2016.08.019]. *Pediatr Neurol*. 2016;56:8-17. doi:10.1016/j.pediatrneurol.2016.01.016
- Powers WJ, Rabinstein AA, Ackerson T, et al. 2018 Guidelines for the Early Management of Patients With Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association [published correction appears in Stroke. 2018 Mar;49(3):e138. doi: 10.1161/STR.0000000000000163] [published correction appears in Stroke. 2018 Jun;49(6):e233-e234. doi: 10.1161/STR.0000000000000172]. *Stroke*. 2018;49(3):e46-e110. doi:10.1161/STR.0000000000000158
- Ferriero DM, Fullerton HJ, Bernard TJ, et al. Management of Stroke in Neonates and Children: A Scientific Statement From the American Heart Association/American Stroke Association. Stroke. 2019;50(3):e51-e96. doi:10.1161/STR.0000000000000183

Return to SND Algorithm

Quality Measures

- Arrival to orderset use
- Arrival to image final
- % of patients getting MRI over CT Head
- Missed patients

Return to SND Algorithm

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Clinical Pathway Development

This clinical pathway was developed using the process described in the NCH Clinical Pathway Development Manual Version 6, 2022. Clinical Pathways at Nationwide Children's Hospital (NCH) are standards which provide general guidance to clinicians. Patient choice, clinician judgment, and other relevant factors in diagnosing and treating patients remain central to the selection of diagnostic tests and therapy. The ordering provider assumes all risks associates with care decisions. NCH assumes no responsibility for any adverse consequences, errors, or omissions that may arise from the use or reliance on these guidelines. NCH's clinical pathways are reviewed periodically for consistency with new evidence; however, new developments may not be represented, and NCH makes no guarantees, representations, or warranties with respect to the information provided in this clinical pathway.

For more information about our pathways and program please contact:
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Return to SND Algorithm

NIH Stroke Scale

National Institutes of Health Stroke Scale score	
1a. Level of consciousness	0 = Alert; keenly responsive 1 = Not alert, but arousable by minor stimulation 2 = Not alert; requires repeated stimulation 3 = Unresponsive or responds only with reflex
1b. Level of consciousness questions: What is the month? What is your age?	0 = Answers two questions correctly 1 = Answers one question correctly 2 = Answers neither question correctly
1c. Level of consciousness commands: Open and close your eyes. Grip and release your hand.	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
3. Visual	0 = No visual loss 1 = Partial hemianopia 2 = Complete hemianopia 3 = Bilateral hemianopia
4. Facial palsy	0 = Normal symmetric movements 1 = Minor paralysis 2 = Partial paralysis 3 = Complete paralysis of one or both sides
5. Motor arm 5a. Left arm 5b. Right arm	0 = No drift 1 = Drift 2 = Some effort against gravity 3 = No effort against gravity; limb falls 4 = No movement
6. Motor leg 6a. Left leg 6b. Right leg	0 = No drift 1 = Drift 2 = Some effort against gravity 3 = No effort against gravity 4 = No movement
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 = No aphasia; normal 1 = Mild to moderate aphasia 2 = Severe aphasia 3 = Mute, global aphasia
10. Dysarthria	0 = Normal 1 = Mild to moderate dysarthria 2 = Severe dysarthria
11. Extinction and inattention	0 = No abnormality 1 = Visual, tactile, auditory, spatial, or personal inattention 2 = Profound hemi-inattention or extinction

Total score = 0–42.

Return to SND Algorithm