



THE UNIVERSITY OF
CHICAGO
MEDICINE

Comer Children's Hospital

AT THE FOREFRONT OF *KIDS'* MEDICINE®



Pediatric Neurology Vade Mecum

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Antiepileptic Medications in Pediatric Neurology

Phenobarbital: 20mg/5mL tabs: 15mg, 30mg, 60mg, 100mg; **Loading** 20mg/kg (not exceed 300mg/dose); **Maintenance** 4-7 mg/kg/day; **Level** 14-40 (4 hours after load)

Phenytoin/Fosphenytoin (Dilantin): 125mg/5mL, Caps 50mg chewable, 30mg, 100mg, 200mg, 300mg; **Loading** 15-20mg/kg single or divided; **Maintenance** 5-10mg/kg/day (no exceed 300mg/day); **Level** total 10-20, Free 1-2 (**use Fosphenytoin IV**)

Carbamazepine (Tegretol, Carbatrol): 100mg/5mL, Caps 100mg chewable, 100mg, 200mg, 300mg, 400mg; **Maintenance** 10-40mg/kg/day; **Level** 8-12

Oxcarbazepine (Trileptal): 300mg/5mL, Tabs: 150mg, 300mg, 600mg; **Maintenance** 20-60mg/kg/day

Valproate (Depakote, Depakene, Depakon): 250mg/5mL, sprinkles 125mg, Tabs 125mg, 250mg, 500mg; **Loading** 10mg/kg; **Maintenance** 20-60mg/kg/day; **Level** 50-200 (**VPA Loading: (Goal level-current level) X Wt (kg) X Volume of distribution. Volume of distribution is ~0.2 in adults and ~ 0.4 in children**)

Lamotrigine (Lamictal): Tabs 5mg, 25mg chewable, 100mg, 150mg, 200mg; **Maintenance** 5-15mg/kg/day (start at 0.3mg/kg/day if not on VPA, 0.15mg/kg/day if on VPA); **Level** 2.5-15

Levetiracetam (Keppra): 100mg/mL, Tabs 250mg, 500mg, 1000mg; **Maintenance** 20-60mg/kg/day

Topiramate (Topamax): 6mg/mL, sprinkles 15mg, 25mg, Tabs 25mg, 50mg, 100mg, 200mg

Start 1-2mg/kg/day **Maintenance** 5-10mg/kg/day **Level** 2-25

Ethosuximide (Zarontin): 250mg/5mL caps 250mg; **Maintenance** 15-40mg/kg/day; **Level** 40-100

Lacosamide (Vimpat): 10mg/mL, Tabs 50mg, 100mg, 150mg, 200mg;

Start 1 mg/kg/day, **Max** 5-10 mg/kg (max 200mg BID)

Clobazam (Onfi): Tabs 10mg, 2.5mg/mL **Start** 5mg QHS; **Maintenance** 1-2mg/kg/day, **Max** 40mg/day

Clonazepam (Klonopin): Tabs 0.5mg, 1mg, 2mg; **Maintenance** 0.1-0.2mg/kg/day

Rufinamide (Banzel): 40mg/mL, Tabs 200mg, 400mg; **Start** 10mg/kg/day, **Maintenance** 45mg/kg/day
Max dose 3,200mg/day

Vigabatrin (Sabril): 50mg/mL, Tabs 500mg, **Start** 50mg/kg/day, **Max dose** 150mg/kg/day

Serum Drug Levels

Oxcarbazepine	8-35 mcg/mL
Carbamazepine	4-12 mcg/mL
Ethosuximide	40-100 mcg/mL
Felbamate	40-65 mcg/mL
Lamotrigine	1.5-15 mcg/mL
Phenytoin	10-20 mcg/mL (Free 1-2)
Phenobarbital	15-40 mcg/mL
Topiramate	2-25 mcg/mL
Valproate	50-100 mcg/mL
Zonisamide	10-20 mcg/mL
Rufinamide	3-30 mcg/mL

Adverse Effects of Anti-seizure Medications in Children

Medications	Common side effects	Serious side effects
Carbamazepine (Tegretol)	Dizziness, vertigo, ataxia Diplopia Hyponatremia (tend to be asymptomatic) Worsen myoclonus and absence	Hepatotoxicity Steven-Johnson syndrome (beware HLA-B1502 in Han Chinese population)
Clobazam (Onfi)	Drowsiness, somnolence, short attention span Hypersalivation (increased drooling) Weight gain	CVS and RS suppression (dose dependent)
Ethosuximide (Zorontin)	Nausea, vomiting Abdominal pain (better to give with meal)	Leukopenia Depression, memory problems
Felbamate (Felbatol)	Headache Insomnia Weight loss (from decreased appetite)	Fatal hepatotoxicity Aplastic anemia
Fosphenytoin/ Phenytoin (Dilantin)	Nystagmus Ataxia, incoordination Worsen myoclonus and absence Coarse faces, Hirsutism (long-term use) Gingival hypertrophy (long-term use) Altered vitamin D metabolism	Hepatotoxicity Cardiac arrhythmia (can be life-threatening) Paradoxical seizure (from suprathreshold level) Cerebellar atrophy (long-term use) Drug-induced SLE Fetal hydantoin syndrome
Lacosamide (Vimpat)	Dizziness, headache Diplopia	Ataxia, impaired balance Cardiac arrhythmia

Adverse Effects of Anti-seizure Medications in Children

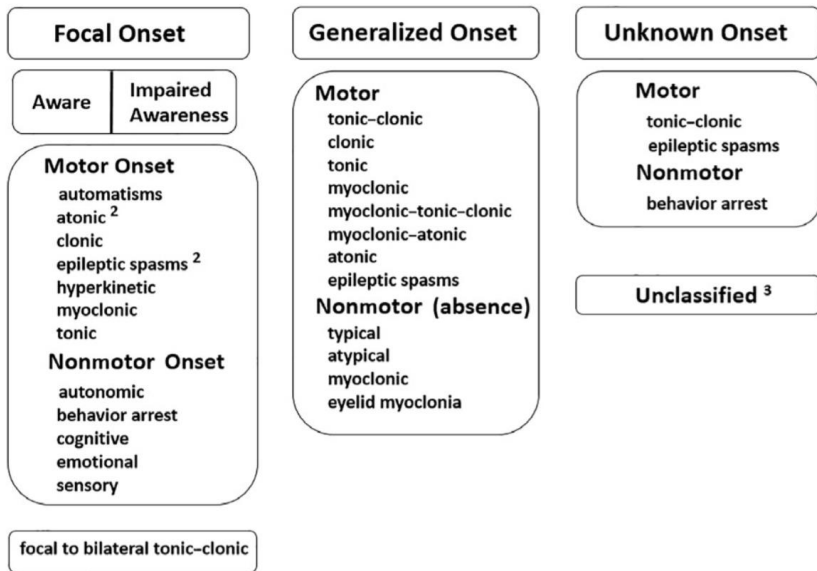
Medications	Common side effects	Serious side effects
Lamotrigine (Lamictal)	Fatigue, confusion May worsen myoclonus (~7%)	Steven-Johnson syndrome, TEN (titration dependent)
Levetiracetam (Keppra)	Aggression, irritability, nervousness	Psychosis
Oxcarbazepine (Trileptal)	Hyponatremia (tend to be asymptomatic) Dizziness, vertigo, ataxia (less frequent than CBZ) Diplopia (less frequent than CBZ) Worsen myoclonus and absence	Hepatotoxicity Steven-Johnson syndrome (beware HLA-B1502 in Han Chinese population)
Parampanel (Fycompa)	Aggression	Suicidality Psychosis
Phenobarbital	Drowsiness, sedation Effect on cognition (long-term use) Hyperactivity and irritability (long-term use) Altered vitamin D and K metabolism (causing low vit D and K)	Hepatotoxicity Withdrawal seizure (from abrupt discontinuation) Connective tissue changes (contracture, fibroma) Respiratory suppression (dose dependent)
Rufinamide (Banzel)	Somnolence Nausea, vomiting Pyrexia	QT prolongation

Adverse Effects of Anti-seizure Medications in Children

Medications	Common side effects	Serious side effects
Topiramate (Topamax)	Impaired concentration Somnolence Word-finding difficulty Cognitive dysfunction Paresthesia Weight loss (from decreased appetite)	Kidney calculi Increased intra-ocular pressure (beware in glaucoma) Oligohydrosis (lead to hyperthermia)
Valproate (Depakote)	Weight gain (from increased appetite) Nausea, vomiting, abdominal pain Tremor Hair loss (temporary and may be prevented with zinc supplement) Thrombocytopenia (dose dependent)	Acute encephalopathy Hyperammonemia Hepatotoxicity (can be fatal in POLG1 mutation) Pancreatitis Mitochondrial dysfunction Secondary carnitine deficiency Fetal major congenital malformation
Vigabatrin (Sabril)	Drowsiness, somnolence Change of muscle tone Non-specific white matter signal change	Irreversible visual field restriction (particularly in the nasal sides)
Zonisamide (Zonogran)	Fatigue Altered thinking	Oligohydrosis (leads to hyperthermia) Kidney calculi

Seizure: A transient occurrence of signs and/or symptoms due to Abnormal excessive or synchronous neuronal activity in the brain.

ILAE 2017 Classification of Seizure Types Expanded Version ¹



DIASTAT (Diazepam rectal gel)

Dosing recommendations by age and weight

2 - 5 Years 0.5 mg/kg	
Weight (kg)	Dose (mg)
6 to 10	5
11 to 15	7.5
16 to 20	10
21 to 25	12.5
26 to 30	15
31 to 35	17.5
36 to 44	20

6 - 11 Years 0.3 mg/kg	
Weight (kg)	Dose (mg)
10 to 16	5
17 to 25	7.5
26 to 33	10
34 to 41	12.5
42 to 50	15
51 to 58	17.5
59 to 74	20

12+ Years 0.2 mg/kg	
Weight (kg)	Dose (mg)
14 to 25	5
26 to 37	7.5
38 to 50	10
51 to 62	12.5
63 to 75	15
76 to 87	17.5
88 to 111	20

Antiepileptic Medications of Choice

Depends on seizure type, syndrome, medication side effect profile, administration, dosing, and parental choice.

1. **Neonatal seizure:** Phenobarbital, Phenytoin, Levetiracetam
2. **Genetic Generalized Epilepsies:** Valproate, Topiramate, Lamotrigine, Zonisamide, Levetiracetam, Clobazam
3. **Narrow spectrum:** Carbamazepine, Oxcarbazepine, Lacosamide, Phenytoin, Phenobarbital, Vigabatrin
4. **Status epilepticus:** Benzodiazepine, Phenytoin, Phenobarbital, Valproate, Levetiracetam
5. **Absence:** Ethosuximide, Valproate, Lamotrigine (avoid Sodium channel blockers)
6. **Juvenile myoclonic epilepsy:** Valproate, Lamotrigine, Levetiracetam (avoid Sodium channel blockers)
7. **Rolandic epilepsy (if treating):** Carbamazepine, Oxcarbazepine, Levetiracetam
8. **ESES/CSWS:** Diazepam, corticosteroids, Valproate, Clobazam, Topiramate, Ethosuximide
9. **Lennox-Gastaut syndrome:** Valproate, Felbamate, Topiramate, Lamotrigine, Clobazam, Rufinamide
10. **Dravet Syndrome:** Valproate, Clobazam, Stiripentol (avoid Sodium channel blockers)
11. **Infantile Spams:** ACTH, Vigabatrin, Corticosteroids

Drug Facts:

Enzyme inducers: PHT, PB, CBZ, OXC

Enzyme inhibitor: VPA

HLA-B1502 increased risk of SJS/TEN in Asian population with CBZ,OXC,PHT

Convulsive Status Epilepticus Protocol for Pediatric Inpatients

Status Epilepticus = seizure > 5 min or frequent seizures without return to baseline in between

Time	Supportive Care	Antiseizure Meds (ASM)	Evaluation
0 - 5 min	Airway, breathing, circulation	Confirm any meds give in the last 12 hours ¹	Hx: fever, trauma, ingestion, prior hx of seizure/epilepsy
	Cardiac Monitor Pulse Ox Start timing the seizure	If hypoglycemic give dextrose 10% 2.5 mL/kg (unless pt on ketogenic diet, see keto protocol)	Exam: temperature, blood pressure, signs of trauma, mental status, ask patient questions and give commands
	Page 1st contact provider		Labs: POC glucose, electrolytes, Ca, Mg, CBC, tox screen, ASM levels ²
5 - 10 min	Page Ped Neuro 7678	1st Line No IV Access: IntraNasal Midazolam 0.2 mg/kg (max 10mg), give 1/2 dose up each nostril	Assess mental status
	If cardiorespiratory compromise, call PET ³	IV Access: Lorazepam, 0.1 mg/kg, (max 4mg/dose), IV push	Screen for seizure risk factors ⁴
10 - 15 min	Place IV	Give 2nd dose of 1st Line¹ IN Midazolam or IV Lorazepam	Assess mental status
15 - 25 min	Monitor closely for respiratory failure and hypotension ²	2nd Line - Levetiracetam 60 mg/kg IV Alternate - Fosphenytoin 20 PE/kg IV	Assess mental status
	Call PET and prepare for transfer to PICU		If cause of seizure remains unknown: order CT head, and consider lumbar puncture
25 - 35 min	Prepare for transfer to PICU	3rd Line - Fosphenytoin 20 PE/kg IV Alternate - • Valproic acid 30 mg/kg IV (max 3g) • Lacosamide 8 mg/kg IV • PHenobarbital 20 mg/kg IV (max 300mg)	Place 24hr video EEG order, and contact EMU 43665
			Assess mental status
35+ min	Transfer patient to PICU	Continuous IV Infusion - titrate to seizure cessation	EEG monitoring - depth of EEG coma should be determined on a case-by-case basis
	Continuous cardiopulmonary monitoring	• Midazolam - bolus 0.2 mg/kg (max 10mg), infusion 0.1 to 2 mg/kg/hr (increase by 0.1 mg/kg/hr every 10-15 minutes, re-bolus with each increase) OR • PENTobarbital - bolus 5 to 10 mg/kg over 1-2 hrs, infusion 0.5 to 5 mg/kg/hr (increase by 0.5-3 mg/kg/hr)	Blood gasses and metabolic testing as appropriate for monitoring for complications of prolonged induced coma. PenTobarbital suppresses fever and causes ileus.

1 If patient has received a rescue dose of benzodiazepine within the past 2 hours, then only give one dose of 1 dose benzodiazepine before moving on to 2nd line ASM

2 Labs: It is not necessary to repeat CBC, tox screen and ASM levels if obtained within last 24h

3 If patient has respiratory failure, activate PET, intubate and skip ahead to Continuous IV Infusion with EEG monitoring

4 Seizure risk factors: prematurity, developmental delay/regression, family history, hx of meningitis, encephalitis, head trauma or sepsis

Please refer to the Pediatric Status Epilepticus Protocol online for further details

Febrile Seizures (3mo to 5yrs)

Incidence 2-5%, 25-40% have family history: genetic epilepsy with febrile seizures plus (GEFS+) involving SCN1A, 2A, 1B and GABRG2 mutations

Spectrum: febrile seizures → GEFS+ → Dravet Syndrome

Simple	Complex (20-30%)	Febrile status
< 15 min	> 15 min	>30 min
Non-focal	Focal	
1 episode during illness	> 1 event during 24hr/illness	
No Todd's paralysis	Todd's paralysis	

Management:

- Treat infection and fever
- LP guidelines per AAP 2012:
 - > Should be performed in all children with signs, symptoms, or history concerning for CNS infection
 - > Optional in 6-12mo olds with unknown vaccination history or deficient in Hib/strep pneumo
 - > Optional in children who have been pre-treated with antibiotics as this may mask meningeal signs
- Imaging not warranted unless clinical suspicion for an acute neurological condition or focal hemi-convulsions suggesting possible structural abnormality
- EEG: up to 1/3 will show transient EEG abnormalities in complex febrile seizures and febrile status epilepticus
- Treat febrile status epilepticus like non-febrile status; be cautious in children with sodium channelopathies (such as Dravet) where sodium channel blockers such as fosphenytoin are contraindicated

Neurologic Emergencies

Refractory Status Epilepticus

(Titrate to cessation of electrographic seizures or burst suppression – depth of EEG coma should be determined on a case-by-case basis)

Midazolam: Loading dose 0.2 mg/kg (max 10 mg), Continuous infusion 0.1 mg/kg/hr, increase by 0.1 mg/kg/hr every 10-15 minutes (re-bolus with each rate increase), max rate of 2 mg/kg/hr as hemodynamic stability permits

Pentobarbital: Loading dose 5-10 mg/kg over 1-2 hours, Continuous infusion 1 mg/kg/hr, increase by 0.5-3 mg/kg/hr, max rate of 5 mg/kg/hr (when tapering, decrease by 0.5 mg/kg every 12 hours)

Ketamine: Loading dose 0.5-2 mg/kg, Continuous infusion 0.3-1.2 mg/kg/hr (5-20 mcg/kg/min)

Increased ICP

Elevate HOB 30 degrees

Mannitol 0.25-1 g/kg/dose IV

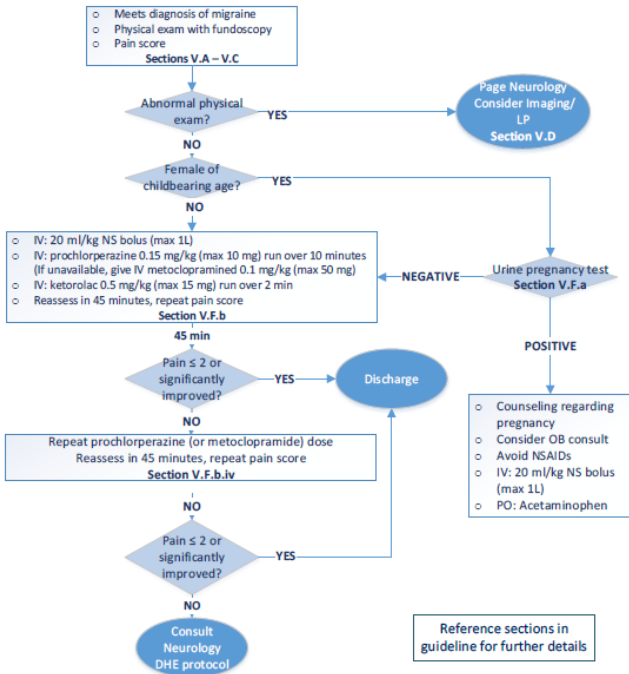
3% NaCl 6 cc/kg run at 1 cc/min

Sedation and analgesia

Cerebral Edema

Dexamethasone: IV/PO Loading dose 1-2 mg/kg/dose, Maintenance dose 1-1.5 mg/kg/day divided every 4-6 hours (max 16 mg/day)

Migraine Management



Pediatric Acute Stroke Guideline

Patients who present within 4.5 hrs → activate Stroke Code (Dial 144)

If patient has sickle cell disease, page Hematology fellow on call

Initial Management:

- ABCs, place on cardiac monitor
- Complete Peds NIHSS, full neuro exam
- Staff patient with Dr. Henry David (661-373-1924)
- Place 2 PIVs – 0.9NS bolus 10 ml/kg (max 1000 ml)
- STAT labs: CBC, CMP, coags, T/S (+/- Hgb electrophoresis, retic)
- Stat head CT wo* → consider tPA (assess inclusion/exclusion criteria)
- EKG, CXR, UA (+/- Utox, ETOH, AED levels)
- Head of bed flat unless hemorrhagic stroke, NPO, vital signs and neurocheck q2h for at least 24hrs then q4h

Additional Imaging:

- *Consider CTA head/neck after CTH obtained based on degree of suspicion for embolic stroke/clot
- MRI brain wo and MRA brain/neck wwo if CTA not obtained

BP Management:

Notify and treat if systolic or diastolic BP >95%ile on >3 repeated measurements

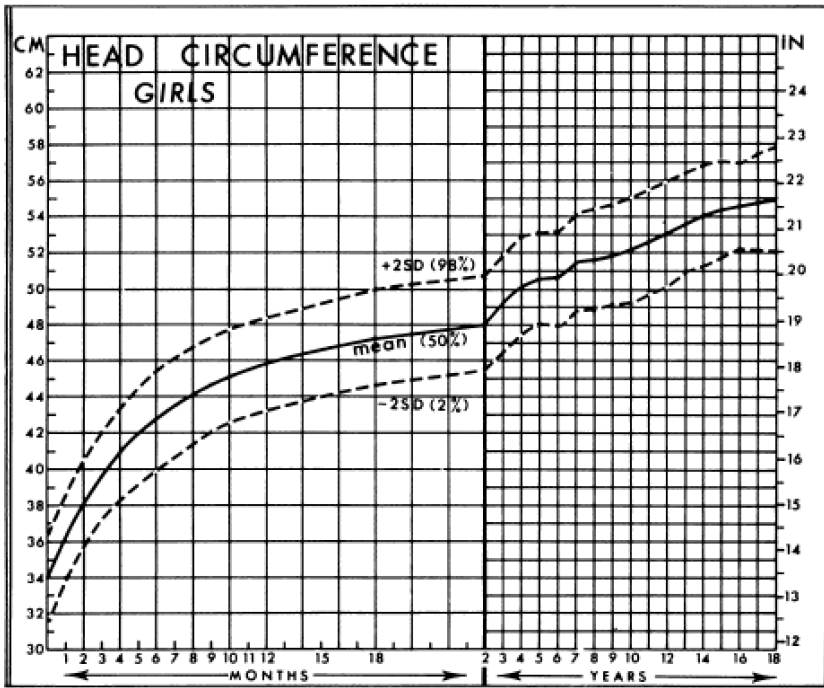
In setting of hemorrhage, maintain BP >50%ile and <95%ile

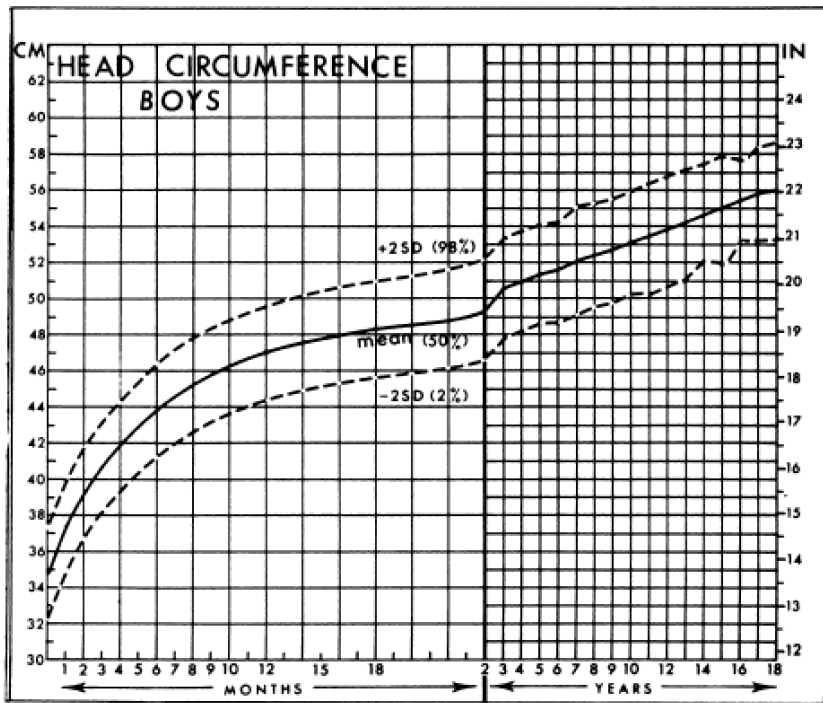
- Labetalol: 0.2-1 mg/kg/dose q4-6 hrs (max 40 mg/dose)
- Hydralazine: 0.1-0.2 mg/kg/dose q4-6hrs (max 20 mg/dose)
- Nicardipine infusion if requiring multiple PRNs: 0.5-1 mcg/kg/min, nurse to titrate to goal BP

Further management:

- If new onset ischemic stroke → LDL, HbA1C, TSH, ESR/CRP, TTE, start ASA 3-5 mg/kg/day, DVT prophylaxis SCD and/or Hep 5000 units SQ BID, consult PT/OT/ST
- Consider hypercoagulable workup: Antithrombin III, Protein C/S, Factor V Leiden, Prothrombin Mutation, Homocysteine level, Anticardiolipin IgM/IgG, Thrombin Time
- Consider hematologic conditions: PT20210 and MTHFR gene mutation, Lipoprotein A, Factors II, VIII, XI level
- Consider metabolic syndrome: lactate, pyruvate, ammonia, CK, plasma amino acid, urine organic acid







Age	Gross Motor	Fine Motor	Language and Cognition
1 mo	Head up while prone	Hands fistled	Fixed and follow
2 mo	Chest up in prone	Hands unfisted 50%	Social smile, regards speaker
4 mo	Roll front to back, no head lag	Hands to midline, reach for objects	Social laugh
6 mo	Roll back to front, sit w/o support	Transfer objects, hold bottle	Babbling
9 mo	Crawling, pull to stand	Bangs 2 toys, starts pincer grasp	Orient to name, "peek-a-boo", understands "NO", finds hidden object
12-15 mo	Walking +/- 3mo	Imitate scribble, tower of 2 blocks	Knows 1-2 body parts, says "NO", follows simple commands, few words
18 mo	Walk up stairs, throw ball, jump	3 cube tower	20 words, 3 body parts
24 mo	Run, jump, kick ball, walk up and down stairs	Draw vertical line	Follow 2-step command, 2 word sentences, refers to self by name
3 yr	Rides a tricycle	Turns door knob, copy a circle, independent eating	Gives full name, knows age and gender, toilet training
4 yr	Hop on 1 foot, alternate feet descending stairs	Copy a cross, dress, buttons	Colors, counting, fantasy play, tells stories
5-6 yr	Walk on tiptoes, skips, catches ball	Copy a triangle	Knows L and R, age and birthday, days of week, Bday, reading
7-8 yr	Tandem walk	Ties shoes, combs hair, print name	Days of the week, add/subtract, tells time