

- 1) **Arousal or wakefulness**, which is dependent on the function of the Reticular Activating System (RAS), a network of neurons located in the core of the brainstem extending from mid pons through the midbrain/hypothalamus to thalamus.
- 2) **Awareness**, which is mediated through cerebral cortical neurons and their reciprocal projections to and from the major subcortical nuclei. Awareness requires arousal, but not vice versa.

Following from the above, coma will result if there is either RAS or cerebral cortical dysfunction. RAS dysfunction, mostly caused by structural lesions in the brain stem tend to present with focal neurologic findings while cerebral cortical dysfunction is often caused by Toxic/Metabolic processes and present with non-focal neurologic findings.

2. Questions to ask

a) Timing

- Acute onset – Suggests intracranial hemorrhage, non-convulsive status seizures, ischemic stroke, or acute trauma
- Onset of minutes to hours – Suggests a metabolic cause, infection, or progressive injury from trauma
- Onset of hours to days – Suggests a shunt blockage, hydrocephalus, or tumor

b) Associated symptoms

- Fever – Infections
- Preceding headache – Increased ICP
- Preceding somnolence – Toxic/Metabolic
- Ataxia, confusion or loss of milestones in recent weeks – Neoplasm

*** Always be cautious of a history that is inconsistent with presentation, as this might suggest non-accidental injury (e.g. shaken baby syndrome)

3. Differential diagnosis

Classification of the different causes of coma can be broadly divided into structural-intrinsic or metabolic-toxic.

Table 1: Selected Etiologies of Impaired Consciousness and Coma

Structural/Intrinsic	Metabolic-toxic
Trauma concussion, contusion, epidural or subdural hematomas, diffuse axonal injury, non-accidental injury	Hypoxia-ischemia shock, near drowning, cardiac or pulmonary failure, CO poisoning, strangulation
Neoplasm Particularly tumors blocking CSF drainage and causing hydrocephalus/herniation	Metabolic disorders hypoglycemia, DKA, hepatic encephalopathy, uremia, vitamin deficiency, fluid electrolyte imbalance
Vascular cerebral infarct, cerebral hemorrhage, vasculitis, congenital abnormality of blood supply	Exogenous toxins and poisons narcotics, MAOI, antidepressants, antiepilepsy meds, cyanide, heavy metals, EtOH, cocaine, heroin
Focal infection empyema, abscess, cerebritis	Infections Bacterial (e.g. Rickettsia), viral
Hydrocephalous Shunt blockage, tumor	Paroxysmal disorders epilepsy, migraine

*** The mnemonic "TIPS VOWELS" (AEIOU) is commonly used to remember the causes of coma.

- T** Trauma
- I** Infection (systemic and neurologic)
- P** Psychiatric
- S** Space occupying lesion, stroke

- A** Alcohol and drugs/toxins
- E** Endocrine, environment
- I** Insulin (hypo/hyperglycemia)
- O** Oxygen (hypoxia), Opiates
- U** Uremia

4. Physical Examination

a) Primary survey

- **Airway** (with C-spine precautions)
The tongue is the most common cause of obstruction in the unconscious child. Intubation is needed for:

- GCS less than 9 ([link to pediatric GCS](#))
 - Poor airway or impending loss of airway
 - Raised ICP (to optimally ventilate)
 - Precaution during transport or CT scanning
- **Breathing** – must assure adequate oxygenation and ventilation
 - **Circulation** – Is the patient in shock? Check pulses, BP, HR, perfusion, temperature. Is Cushing response (↑BP, ↓HR, abnormal breathing pattern due to ↑ICP) present? Establish IV access.
 - **Disability**- Glasgow Coma Scale and Glasgow Coma Scale-modification for children ([link to pediatric GCS](#)) are useful for objective evaluation and quantification of the consciousness-coma continuum. Note, however, it does not account for the important brainstem reflexes (pupillary, oculocephalic, oculovestibular, corneal).

b) Secondary survey

- **Head and Neck**
 - Bruises, cephalohematoma, swelling suggest cranial trauma.
 - Bleeding or clear fluid from nose or ears suggest basilar skull fracture.
 - Check fundi for papilledema (increased ICP) and hemorrhage (occult trauma).
 - Many metabolic/toxic causes for coma result in symmetrically small pupils with preserved reactivity to light. Hypoxic-ischemic injury produces symmetric dilated pupils that may not respond to light.
 - Passive resistance to neck flexion suggests meningeal irritation, tonsillar herniation.
 - Positive Kernig's and Brudzinski's sign can also indicate meningeal irritation.
 - Cranial Nerve Exam:
 - II, IV, VI - Extra ocular movement (brainstem integrity)
(Note that the Oculocephalic reflex should

not be done if neck injury is suspected)

- V, VII - Corneal reflexes. A normal response is bilateral closure of eyelids after unilateral stimulation of the cornea. Metabolic causes tend to produce bilateral loss of response.

IX, X - Gag reflex

□ **Sensory and Motor reflexes**

- Sensation is grossly tested through the GCS evaluation ([link to pediatric GCS](#))
- Deep tendon reflex (DTR) and/or motor tone asymmetry are important focal findings.
- Posturing indicates level of disease in midbrain with reference to the red nucleus:
 - a) Flexor (previously called decorticate): Arms flexed and hands towards midline; legs extended. Indicates damage above the level of the red nucleus in midbrain.
 - b) Extensor (previously called decerebrate): Arms and legs extended; teeth clenched. Indicates severe disease involving central midbrain below the level of the red nucleus.

□ **Cardiovascular**

- Congenital heart disease or endocarditis may be sources of intracranial thrombi.

□ **Skin**

- Cyanosis – poor oxygenation
- Jaundice – liver failure
- Extreme pallor – anemia or shock
- Cherry red skin – CO poisoning
- Rashes – may be seen with certain infections such as meningococemia
- Increased pigmentation – Addison's Disease
- Neuro-cutaneous lesions – e.g. tuberous sclerosis may suggest intracranial tumor

□ **Odor of exhaled breath**

- EtOH intoxication
- DKA (sweet fruity)
- Uremia (urine like)
- Hepatic coma (musty)

5. Investigations

a) Laboratory investigations

- CBC + differential
- Electrolytes
- Bilirubin

- ❑ Albumin
- ❑ Coagulation profiles
- ❑ Liver enzymes
- ❑ Creatinine
- ❑ BUN
- ❑ Ca^{2+} , Mg^{2+} , PO_4
- ❑ Ammonia
- ❑ Lactate
- ❑ Tox. Screen
- ❑ Glucose

b) Imaging Studies

- ❑ CT/MRI when patient is medically stable. CT offers faster results, but MRI may be better for herpes simplex encephalopathy, or for acute disseminated encephalomyelitis.
- ❑ Lumbar puncture should be performed if ICP is not elevated and there is a suspicion of CNS infection.
- ❑ EEG is essential to diagnose nonconvulsive status epilepticus. May also be useful in serial assessment of persistent coma or status epilepticus.
- ❑ Neurosurgical consult if appropriate.

References

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Acknowledgements

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