Nervous System Disorders in Critical Care

Chapter 318 | Part 8: Critical Care Medicine

KEY CLINICAL POINTS

1. Encephalopathy is a general term for diffuse, global, or multifocal brain dysfunction.
2. Brain edema consists of vasogenic (BBB failure) and cytotoxic (cellular swelling) components.
3. Cerebral autoregulation maintains constant blood flow; CPP = MAP - ICP.
4. Target goals: ICP <20 mmHg and CPP ≥60 mmHg.
5. Hypoxic-ischemic injury prognosis is better with intact brainstem function (pupillary, oculocephalic, oculovestibular, corneal reflexes).
6. Secondary insults (hypotension, hypoxia, fever, hyperglycemia) must be aggressively managed to prevent worsening of primary injury.
7. Targeted temperature management (TTM) for post-arrest patients: 32–37.5°C.
8. Sepsis-associated encephalopathy presents as diffuse dysfunction without prominent focal findings.
9. Prognostic indicators include EEG burst-suppression, absent N20 SSEP, and NSE >60 µg/L.
10. Hyperventilation (PaCO2 30–35 mmHg) is for short-term use only to avoid rebound ICP.

DEFINITION & CLASSIFICATION

- **Neurologic Critical Care:** Focuses on preservation of tissue and prevention of secondary injury (ischemia, hemorrhage, edema, herniation, elevated ICP).
- **Encephalopathy:**

Definition (Harrison's 22e): *Encephalopathy is a general term describing brain dysfunction that is diffuse, global, or multifocal.*

- **Severe Acute Encephalopathies:** Group of disorders with varying etiologies sharing common themes of primary and secondary injury.
- **Systemic Links:** May result from local neuro-axis issues or systemic failures (hepatic failure, multi-system organ failure, cardiac arrest).

EPIDEMIOLOGY

- **Sudden Cardiac Death (SCD):**
  - Only ~20% occur in patients with poor left ventricular function.
  - Most occur in individuals with preserved ventricular function (LVEF >35%).
  - Prevention focuses on risk factor modification and standard medical therapy.

ETIOLOGY & PATHOPHYSIOLOGY

Brain Edema

- **Vasogenic Edema:** Influx of fluid/solutes due to incompetent blood-brain barrier (BBB).
  - Triggered by ischemia, trauma, infection, or metabolic derangements.
- **Cytotoxic Edema:** Results from cellular swelling and membrane breakdown leading to cell death.
- **Clinical Impact:** Leads to increased ICP, tissue shifts, and potential herniation.

Ischemic Cascade & Cellular Injury

- **Mechanism:** Inadequate oxygen/glucose → release of glutamate → influx of Ca^{2+} and Na^{+} → activation of proteases/lipases → lipid peroxidation → cell death.
- **Penumbra:** Area of ischemic tissue not yet irreversibly infarcted; potentially salvageable if ischemia is reversed.
- **Secondary Insults:** Factors that exacerbate primary injury (e.g., hypotension, hypoxia, fever, seizures, hyperglycemia).

Apoptosis

- **Definition:** Programmed cell death occurring in stroke, global ischemia, trauma, or hemorrhage.
  - Distinct from necrosis: No cerebral edema; often not visible on imaging.

Cerebral Perfusion & Autoregulation

- **Cerebral Perfusion Pressure (CPP):** Defined as MAP minus ICP. Provides driving force for capillary circulation.
- **Autoregulation:** Mechanism where CBF is maintained via changes in cerebrovascular resistance despite wide ranges of systemic blood pressure.
  - Low BP → vasodilation of arterioles to preserve flow.
  - High BP → arteriolar vasoconstriction to prevent hyperperfusion.
- **Chemical Influence:** CBF increases with hypercapnia and acidosis; decreases with hypocapnia and alkalosis.
- **Hyperventilation Effect:** Reduces ICP by decreasing both CBF and intracranial blood volume (via lower $PaCO_2$).
- **Failure of Autoregulation:** Occurs in traumatic brain injury or severe focal ischemia.

CSF & ICP Dynamics

- **Components:** Cranial contents = brain + CSF + blood.
- **Volume Constraints:** Skull allows little tolerance for extra volume; expansion leads to increased ICP.
- **Vicious Cycle of Ischemia:** Ischemia → vasodilation (autoregulation) → increased cerebral blood volume → increased ICP → lower CPP → further ischemia.

CLINICAL FEATURES

General Assessment

- **Primary Distinction:** Determine if dysfunction is Diffuse (metabolic) or Focal (structural).
  - Diffuse: Metabolic encephalopathies, drug overdose, hypoxia-ischemia.
  - Focal: Stroke, tumor, abscess, hemorrhage, trauma.
- **Red Flags for Structural Lesion:** Pupillary asymmetry, hemiparesis, gaze palsy, visual field deficit.

- **ICP Warning Signs:** Drowsiness and diminished level of consciousness.

Hypoxic-Ischemic Brain Injury

- **Time Sensitivity:** If circulation restored within 3–5 min → potential full recovery; >3-5 min → likely permanent damage.
- **Tolerance:** Brain is more tolerant to pure hypoxia (e.g., high altitude) than to hypoxia-ischemia (cardiac arrest).
- **Prognostic Indicators:**
  - Better Prognosis: Intact brainstem function (pupillary light response, oculocephalic, oculovestibular, and corneal reflexes).
  - Poorer Prognosis:

→ Absent pupillary reflex or absent motor response to pain 5–7 days post-injury.

→ Bilateral absence of N20 component of SSEP after several days.

→ EEG burst-suppression pattern or nonreactive EEG.

→ Serum NSE >60 µg/L during first 1–3 days post-resuscitation.

Specific Syndromes

- **Wernicke's Disease:** Confusion, impaired eye movements, gait ataxia.
- **Hepatic Encephalopathy:** Suggested by asterixis; occurs in liver failure.
- **Sepsis-Associated Encephalopathy:** Diffuse dysfunction without focal findings; includes confusion, agitation, and hyperreflexia/frontal release signs.
- **Postcardiac Bypass Injury:** Includes acute encephalopathy, stroke, and chronic cognitive impairment (often due to embolic disease).

DIFFERENTIAL DIAGNOSIS

- **Metabolic/Diffuse:** Organ failure (hepatic, renal), drug overdose, electrolyte disturbances (hyponatremia, hypoglycemia), hypoxia, meningitis, Wernicke's.
- **Structural/Focal:** Ischemic stroke, tumor, abscess, hemorrhage, trauma.
- **Specific Indicators:**

→ Asterixis → Hepatic encephalopathy.

→ Carbon monoxide poisoning → suggested by cherry red skin (inconsistent) and confirmed by carboxyhemoglobin levels.

DIAGNOSTIC APPROACH

1. **Initial Imaging:** Computed Tomography (CT) scan.

→ Rapidly identifies hemorrhage, hydrocephalus, and tissue shifts.

2. **Advanced Imaging:** Magnetic Resonance Imaging (MRI).

→ Used for specific details like acute ischemic stroke (DWI) or identifying posterior reversible encephalopathy syndrome (PRES).

3. **Neurovascular Imaging:** CT/MR angiography or venography.

→ Identifies arterial occlusion or cerebral venous thrombosis.

4. **Electrophysiology:** Electroencephalography (EEG).

→ Used to identify non-convulsive status epilepticus, burst-suppression patterns, or assess brain activity.

5. **Laboratory Markers:** Serum NSE.

→ Measured in first 1–3 days post-cardiac arrest; >60 µg/L indicates significant damage.

MANAGEMENT & TREATMENT

- **Hypoxic-Ischemic Brain Injury:** Targeted temperature management (TTM) to 32–37.5°C for post-arrest patients without response to verbal commands.

Elevated ICP Management

- **General Goals:** Maintain ICP <20 mmHg and CPP geq60 mmHg.
- **Stepwise Protocol (for ICP >20-25 mmHg for >5 min):**

1. Position: Elevate head of bed; maintain midline head position.
2. Drainage: Drain CSF via ventriculostomy (if in place).
3. Osmotherapy:

→ Mannitol 25–100 g q4h as needed (maintain serum osmolality <320 mOsmL).

→ OR Hypertonic saline (30 mL, 23.4% NaCl bolus).

4. Glucocorticoids: Dexamethasone 4 mg q6h (only for vasogenic edema from tumor or abscess; avoid in head trauma/stroke).
5. Sedation: Morphine, propofol, or midazolam; add neuromuscular paralysis if necessary.
6. Hyperventilation: Target PaCO_2 30–35 mmHg (short-term use only).
7. Pressor Therapy: Phenylephrine, dopamine, or norepinephrine to maintain MAP for CPP geq60 mmHg.
8. Second-tier options (refractory):

→ Decompressive craniectomy.

→ High-dose barbiturate therapy ("pentobarb coma").

→ Hypothermia to 33°C.

PROGNOSIS & COMPLICATIONS

- **Hypoxic-Ischemic Outcomes:** Persistent coma, unresponsive wakeful state (bilateral thalamic scarring), dementia, visual agnosia, parkinsonism, choreoathetosis, cerebellar ataxia, myoclonus, seizures, and amnestic state.
- **Surgical Risks:** Postcardiac bypass may lead to stroke or embolic-related complications.

SPECIAL POPULATIONS

- **Pregnancy/Preeclampsia:** Associated with Posterior Reversible Encephalopathy Syndrome (PRES).

KEY PEARLS & HIGH-YIELD POINTS

- **Rule of Thumb:** Always distinguish between metabolic (diffuse) and structural (focal) causes immediately.
- **ICP Target:** ICP <20 mmHg; CPP geq60 mmHg.
- **Hyperventilation:** Use only as a short-term bridge to avoid rebound ICP elevation.
- **Sepsis Encephalopathy:** Characterized by diffuse dysfunction without focal signs.

REFERENCE TABLES

TABLE 318-1
Neurologic Disorders in Critical Illness

LOCALIZATION ALONG NEUROAXIS	SYNDROME
Central Nervous System	
Brain: Cerebral hemispheres	Global encephalopathy
	Delirium
	Sepsis
	Organ failure—hepatic, renal
	Medication related—sedatives, hypnotics, analgesics, H blockers, antihypertensives 2
	Drug overdose
	Electrolyte disturbance—hyponatremia, hypoglycemia
	Hypotension/hypoperfusion
	Hypoxia
	Meningitis
	Subarachnoid hemorrhage
	Wernicke's disease
	Seizure—postictal or nonconvulsive status epilepticus
	Hypertensive encephalopathy
	Hypothyroidism—myxedema
	Focal deficits
	Ischemic stroke
	Tumor
	Abscess, subdural empyema

LOCALIZATION ALONG NEUROAXIS	SYNDROME
	Intraparenchymal hemorrhage
	Subdural/epidural hematoma
Spinal cord	Mass effect and compression
	Disk herniation
	Epidural hematoma
	Epidural abscess Ischemia—hypotension/embolic
	Trauma
	Myelitis
Peripheral Nervous System	
Neuromuscular junction	Prolonged effect of neuromuscular blockade
	Medication effects—aminoglycosides
	Myasthenia gravis, Lambert-Eaton syndrome, botulism

TABLE 318-2

Stepwise Approach to Treatment of Elevated Intracranial Pressure (ICP) a Insert ICP monitor—ventriculostomy versus...

- Insert ICP monitor—ventriculostomy versus parenchymal device General goals: maintain ICP <20 mmHg and CPP ≥60 mmHg. For ICP >20–25 mmHg for >5 min: 1. Elevate head of the bed; midline head position 2. Drain CSF via ventriculostomy (if in place) 3. Osmotherapy—mannitol 25–100 g q4h as needed (maintain serum osmolality <320 mosmol) or hypertonic saline (30 mL, 23.4% NaCl bolus) 4. Glucocorticoids—dexamethasone 4 mg q6h for vasogenic edema from tumor, abscess (avoid glucocorticoids in head trauma, ischemic and hemorrhagic stroke) 5. Sedation (e.g., morphine, propofol, or midazolam); add neuromuscular paralysis if necessary (patient will require endotracheal intubation and mechanical ventilation at this point, if not before) 6. Hyperventilation—to Paco 30–35 mmHg (short-term use or skip this step) 2 7. Pressor therapy—phenylephrine, dopamine, or norepinephrine to maintain adequate MAP to ensure CPP ≥60 mmHg (maintain euvolemia to minimize deleterious systemic effects of pressors). May adjust target CPP in individual patients based on autoregulation status. 8. Consider second-tier therapies for refractory elevated ICP a. Decompressive craniectomy b. High-dose barbiturate therapy ("pentobarb coma") c. Hypothermia to 33°C

TABLE 318-3

Common Etiologies of Posterior Reversible Encephalopathy Syndrome Disorders in which increased capillary pressure...

- Disorders in which increased capillary pressure dominates the pathophysiology
- Hypertensive encephalopathy, including secondary causes such as renovascular hypertension, pheochromocytoma, cocaine use, etc.

- Postcarotid endarterectomy syndrome
- Preeclampsia/eclampsia
- Disorders in which endothelial dysfunction dominates the pathophysiology
- Calcineurin inhibitor toxicity (e.g., cyclosporine, tacrolimus)
- Chemotherapeutic agent toxicity (e.g., cytarabine, azathioprine, 5-fluorouracil, cisplatin, methotrexate, tumor necrosis factor α antagonists)
- HELLP syndrome (hemolysis, elevated liver enzyme levels, low platelet count)
- Hemolytic-uremic syndrome (HUS)