

Increased ICP (pressure in brain)

Increased ICP (pressure inside the skull) — the box is full, and the brainstem gets squeezed toward the exit.

THE ONE-LINE TRUTH

The skull is a closed box — nothing can expand inside without crushing something else.

The chain — how it unfolds

1. Volume inside the closed skull rises. — why: A mass (blood, tumor, abscess), brain swelling (edema from stroke, trauma, infection, liver failure), CSF buildup (hydrocephalus), or backed-up venous blood adds volume. The skull is rigid bone and cannot stretch, so pressure inside (ICP) must rise. At first, CSF squeezes down into the spinal canal and veins collapse, keeping ICP stable — this is the flat part of the compliance curve.
2. Compensatory reserve exhausts and ICP shoots up. — why: Once all the movable CSF is gone and veins are fully flattened, even a tiny bit more volume makes ICP climb steeply — the compliance curve goes vertical. Now ICP can jump from 15 to 40 mmHg in minutes.
3. Cerebral blood flow (perfusion) pressure (CPP) drops. — why: $CPP = MAP - ICP$. If ICP climbs and MAP stays the same, CPP falls. Below about 50–60 mmHg, blood flow cannot deliver enough oxygen, and neurons start to die (ischemia). Starved blood flow (Ischemia) makes cells swell (cytotoxic swelling (edema)), which raises ICP even more — a vicious cycle.
4. Brainstem compression triggers the Cushing reflex. — why: High ICP squeezes the medulla (the lowest part of the brainstem), crushing the vasomotor center (a cluster of neurons that controls blood vessel tone). These neurons sense they are being strangled and fire in a panic, sending a massive sympathetic surge through the whole body. Arteries everywhere clamp down hard, shooting blood pressure way up (sometimes systolic >200 mmHg). This is the body's last attempt to force blood past the high ICP and keep CPP above the starved blood flow (ischemia) threshold.

5. Heart rate slows (reflex a slow heart rate (bradycardia)). — why: Baroreceptors (pressure sensors) in the aortic arch and carotid arteries detect the dangerously high blood pressure and signal the vagus nerve (cranial nerve X) to slam the brakes on the heart. The pulse drops, sometimes to 40–50 bpm, trying to protect blood vessels from rupturing. Cushing triad = high blood pressure (hypertension) + a slow heart rate (bradycardia) + irregular respirations, and it is a late, ominous sign.
6. Breathing becomes slow, irregular, or stops. — why: The medulla and pons contain the respiratory centers (groups of neurons that set the rhythm and depth of each breath). As ICP crushes these centers, the normal smooth breathing pattern breaks down. You see Cheyne-Stokes (cycles of deep breaths, then shallow, then pauses), uncoordinated (ataxic) breathing (completely chaotic), or apneustic breathing (long gasping inhales with pauses). Eventually breathing stops (apnea) as the medulla fails.
7. Pupils dilate and stop reacting to light. — why: The oculomotor nerve (cranial nerve III) runs along the edge of the tentorium (a shelf of dura inside the skull) and controls the sphincter muscle that shrinks the pupil. When rising pressure pushes the uncus (part of the temporal lobe) or the whole brain downward (herniation), CN III gets stretched and compressed against the tentorial edge or the posterior cerebral artery. Parasympathetic fibers (which constrict the pupil) run on the outside of the nerve and are crushed first, so the pupil dilates and becomes fixed (blown pupil). This often starts on one side (ipsilateral to the mass) and is a neurosurgical emergency.
8. Posturing appears: decorticate, then decerebrate. — why: As the brain herniates downward, it shuts off upper control centers in stages. Decorticate posturing (arms flexed tight to the chest, legs stiff and straight) means the cerebral cortex is offline but the red nucleus (in the midbrain) still has some control. Decerebrate posturing (all limbs extended, arms rotated inward, back arched) means the midbrain is now crushed and only the brainstem (pons, medulla) is firing. Posturing is not a seizure; it is the brain losing its wiring from top to bottom.

Spot it — what you see, and why

- Headache that gets worse when lying down or in the morning: When pressure builds inside the skull, it squeezes pain-sensing tissue around the brain. Lying flat or sleeping lets fluid pool in the head, which pushes pressure even higher.
- Throwing up without feeling sick to the stomach first (projectile vomiting): High pressure presses on the area postrema (a trigger zone at the base of the brain that controls vomiting), setting off the vomit reflex without the usual warning nausea.

- Blurry vision or brief moments when vision goes dark (visual obscurations): Pressure travels along the optic nerve (the cable that sends pictures from the eye to the brain) and squeezes it, blocking signals and sometimes making the back of the eye swell (papilledema).
- Feeling confused, sleepy, or hard to wake up: Rising pressure squeezes the reticular activating system (a network deep in the brainstem that keeps you alert and awake), slowing down the signals that keep your mind clear.
- One pupil becomes larger than the other or stops shrinking in bright light: Pressure pushes part of the brain (the uncus of the temporal lobe) down and traps the oculomotor nerve (cranial nerve III, which controls pupil size). The trapped nerve can't send the 'shrink' signal anymore.
- Seizures: High pressure irritates neurons (brain cells that fire electrical signals), and when many fire together all at once in a chaotic wave, a seizure happens.

Red flags — act now

- Confusion, extreme sleepiness, or impossible to wake up
- One pupil much larger than the other or not reacting to light
- Sudden seizure
- Cushing triad: very high blood pressure, slow pulse, and weird breathing pattern
- Sudden severe headache described as 'the worst of my life'

Treat it — in this order

1. Head of bed elevated 30 degrees, neck midline and straight → Gravity helps venous blood drain out of the jugular veins in the neck, lowering blood volume inside the rigid skull. Keeping the neck straight prevents kinking the veins. This lowers ICP by a few mmHg within minutes.
2. Hypertonic saline (3% continuous infusion or 23.4% bolus) or mannitol 0.25–1 g/kg IV → These hyperosmolar agents pull water out of the swollen brain tissue into the bloodstream through osmosis (water follows salt). This shrinks brain volume and lowers ICP within 15–30 minutes. Hypertonic saline is preferred in trauma because it also supports blood pressure (Neurocritical Care Society). Mannitol works but can drop blood pressure.
3. Sedation and analgesia — propofol infusion, fentanyl boluses → Sedation lowers the brain's metabolic rate (how much oxygen and glucose it burns), which lowers cerebral blood flow and ICP. Pain and agitation spike ICP by raising blood pressure and causing the patient to fight the ventilator. Propofol also has direct neuroprotective effects.

4. Controlled hyperventilation to PaCO₂ 30–35 mmHg → Lowering CO₂ causes cerebral vasoconstriction (brain arteries squeeze smaller), reducing blood volume in the skull and lowering ICP fast. This is a rescue intervention for acute herniation, not a sustained strategy.
5. Drain cerebrospinal fluid via external ventricular drain (EVD) → Draining CSF directly removes volume from the skull box, immediately lowering ICP. This is the fastest mechanical intervention. It also allows continuous ICP monitoring.

Your top priorities at the bedside

1. Position the head of bed at 30 degrees and keep the patient's head and neck in straight midline alignment without any rotation or flexion — why: Elevating the head lets gravity help drain venous blood and cerebrospinal fluid away from the brain, and keeping the neck straight prevents kinking of the jugular veins (neck veins) which would trap blood in the head and raise pressure higher
2. Perform neurological assessments every 1 hour using Glasgow Coma Scale (a 15-point scoring system measuring eye opening, verbal response, and motor movement) and pupil checks with a penlight — why: Declining Glasgow Coma Scale score or a pupil that becomes large and fixed signals brain herniation (brain tissue squeezing downward) is starting, giving only minutes to intervene before permanent brain damage or death
3. Maintain continuous ICP monitoring via the external ventricular drain (EVD) or intraparenchymal bolt (a pressure probe inserted into brain tissue), keeping ICP below 22 mmHg and cerebral blood flow (perfusion) pressure (CPP) above 60 mmHg — why: Cerebral blood flow (perfusion) pressure equals mean arterial pressure minus ICP—it measures actual blood flow reaching brain tissue—and when CPP drops below 60 mmHg the brain does not get enough oxygen and cells begin dying