

TBI · Traumatic Brain Injury

TBI is a knock to the head that bruises or tears the brain. The first job is to stop the bleeding and swelling so the brain does not get hurt a second time.

THE ONE-LINE TRUTH

The brain gets hurt at the moment of impact, then can get hurt again from swelling and pressure afterward.

The chain — how it unfolds

1. Impact tears blood vessels and shears axons. — why: The blow twists or crushes brain tissue, snapping the tiny wires (axons) that carry signals and ripping vessels that feed the brain.
2. Blood leaks and cells start to swell. — why: Broken vessels spill blood into brain tissue or surrounding spaces, and injured cells lose their pumps, letting water flood in.
3. Intracranial pressure (ICP) rises. — why: Swelling and blood take up space inside a hard skull that cannot expand, so pressure climbs—like inflating a balloon inside a jar.
4. Cerebral blood flow (perfusion) pressure (CPP) drops. — why: High ICP squeezes brain arteries from the outside, so even if the heart pumps hard, blood cannot push through and oxygen delivery falls.
5. Brain cells start to die from lack of oxygen (secondary injury). — why: Without fresh blood, neurons run out of glucose and oxygen within minutes and release toxic chemicals (excitotoxicity) that kill neighbors.
6. The brain tries to compensate: blood pressure climbs, heart rate slows, breathing gets choppy (Cushing's triad). — why: The brainstem senses the squeeze and fires an emergency reflex to force more blood in, but this only works briefly before ICP wins.
7. If pressure keeps rising, the brain herniates. — why: Soft tissue gets pushed through skull openings—uncal herniation compresses the brainstem, cutting off signals that control breathing and heart rate.
8. Without urgent treatment, herniation leads to coma, then death. — why: Once the brainstem is crushed, the body loses control of vital functions and cannot recover, even if the heart is still beating.

Spot it — what you see, and why

- Headache that won't go away or gets worse: The impact bruises brain tissue and stretches blood vessels, triggering pain signals. Swelling inside the skull (the closed bone box) pushes on pain-sensitive membranes around the brain.
- Confusion or trouble remembering things: The hippocampus (the brain's memory-maker in the inner fold) and the prefrontal cortex (the front part that organizes thinking) get shaken or bruised. Neurons (nerve cells) can't talk to each other smoothly, so new memories don't stick and thoughts get foggy.
- Dizziness or trouble keeping balance: The cerebellum (the balance center at the back base of the brain) and the inner ear's balance sensors get jarred by the blow. Your brain can't match up the signals from your eyes, ears, and muscles, so the room feels like it's spinning or you wobble when you walk.
- Nausea or vomiting: Swelling and pressure inside the skull irritate the vomiting center in the brainstem (the stalk connecting brain to spinal cord). Rising pressure also squeezes structures that trigger the nausea reflex.
- Feeling sleepy or hard to wake up: Injury to the reticular activating system (a network in the brainstem that keeps you alert) dims the brain's wake-up signal. Swelling or bleeding presses on this area, so the person drifts toward sleep and is slow to respond.
- One pupil bigger than the other, or pupils that don't shrink in bright light: Bleeding or swelling pushes the brain downward and pinches the oculomotor nerve (cranial nerve III), which controls pupil size. A squeezed nerve can't tell the pupil to get smaller, so it stays wide open — a sign of dangerous pressure inside the skull.

Red flags — act now

- Glasgow Coma Scale score below 9 (deep unconsciousness — the brain is badly hurt and the person can't protect their airway)
- One pupil much bigger than the other or pupils that stay wide and don't react to light (sign of a brain bleed pressing on the nerve)
- Repeated vomiting or vomiting that starts hours after the injury (rising pressure inside the skull)
- Seizure after the head injury (the brain's wiring is misfiring from the damage)
- Clear or pink fluid leaking from nose or ears (skull fracture letting brain fluid escape)

Treat it — in this order

1. Secure the airway and intubate if Glasgow Coma Scale ≤ 8 → A breathing tube (endotracheal tube) keeps the airway open so spit, vomit, or blood cannot get into the lungs and cause pneumonia or block oxygen. The tube also lets you control how much oxygen goes in and how much carbon dioxide comes out, which protects the brain from more swelling.
2. Elevate the head of the bed 30 degrees and keep the neck straight in midline → Tilting the head up lets blood and fluid drain out of the skull through the jugular veins (the big veins in the neck), which lowers pressure inside the brain. Keeping the neck straight (not turned or twisted) keeps the jugular veins open so blood can flow out easily.
3. Maintain mean arterial pressure (MAP) 65–70 mmHg and oxygen saturation above 90% → The brain needs a MAP of at least 65 to push blood through swollen, squeezed vessels. Oxygen above 90% keeps brain cells alive. If pressure or oxygen drops, more brain cells die and swelling gets worse.
4. Emergency surgery (craniotomy) to remove large blood clots or decompress the skull if midline shift > 5 mm or deteriorating exam → Surgery physically takes out the pool of blood or removes part of the skull (decompressive craniectomy) to give the swollen brain more room. This drops pressure inside the skull immediately and can save the person's life.
5. Give mannitol 0.25–1 g/kg IV or 3% hypertonic saline bolus for intracranial pressure (ICP) spikes above 22 mmHg → Mannitol and hypertonic saline pull water out of brain tissue into the bloodstream, which shrinks the brain and drops pressure fast (within 15–30 minutes). This buys time while you figure out if the person needs surgery or other treatments.

Your top priorities at the bedside

1. Check airway patency and oxygen saturation every 15 minutes; prepare intubation equipment at bedside if Glasgow Coma Scale is 8 or below. — why: The injured brain needs constant oxygen. If Glasgow Coma Scale drops to 8 or less, the patient cannot protect the airway from vomit or tongue blocking the throat, and low oxygen makes brain swelling worse.
2. Assess pupils every hour: measure size in millimeters, check if both are equal, and shine a light to see if they get smaller. — why: Pupils that stay wide and do not react to light mean a blood clot or swelling is pressing on cranial nerve III (the oculomotor nerve). One blown pupil is a neurosurgical emergency signaling brain herniation (the brain is squeezing downward).

3. Elevate the head of bed to 30 degrees and keep the head and neck in straight midline alignment; avoid neck twisting or flexion. — why: Jugular veins in the neck drain blood away from the brain. When the neck twists or bends, the veins kink and blood backs up, raising intracranial pressure (ICP, pressure inside the skull). Elevation uses gravity to help drainage.