Mechanical Ventilation in Brain Injured Patients

By.Asst.Lect.ALAA ALYASRY

Mechanical Ventilation in Brain Injured Patients

Introduction :

- Patients with brain injury frequently need mechanical ventilation (MV), both to

1.protect the airways and

2.to maintain adequate oxygenation and carbon dioxide (CO2) levels

to minimize secondary brain damage.

- Moreover, **neuro-patients** often develop **respiratory complications**, such as **acute respiratory distress syndrome (ARDS)** which occurs in up to **20–38% of cases** .
- The pathophysiologic relationship behind **brain and lung interaction** **is complex** ; **moreover, due to**

1.the heterogeneity of brain injury and

2.the lack of evidence

there are no ideal ventilatory strategies or precise gas exchange targets that can unanimously be considered beneficial.

Indications for Invasive Mechanical Ventilation in Brain Injured Patients

- The decision to intubate patients with **brain injury** should be **primarily focused on**

  1.the protection of airways to prevent aspiration

  2.the level of consciousness

  3.and level of intracranial pressure (ICP).

- **Particularly**

1.patients with loss of the airway protective reflexes

2. Glasgow Coma Scale (GCS) ≤ 8, and

3.a substantial increase in ICP or signs of brain herniation

should be considered for intubation.

- Moreover, in the presence of **concomitant extra-neurologic conditions** who require intubation, this maneuver should not be delayed.

- **Literature** is scarce regarding the use, indications, and timing of non-invasive ventilation (NIV) in brain injured patients.
- NIV can **potentially** **reduce the need for invasive ventilation**, but it can also increase intrathoracic pressure, without protecting airways and without control CO2 levels.
- in the recent consensus statement providing recommendations on mechanical ventilation in patients with acute brain injury.
- **the panel noted** that the quality of evidence was very low and did not reach consensus on the use of non-invasive respiratory support in this population.
- However, the use of **high flow nasal cannula oxygen therapy** may be considered in patients **with hypoxemic respiratory failure that is refractory to conventional supplemental oxygen.**

Ventilatory Strategies and Targets

Ventilator Settings

- Regarding the ventilator setting there is **a lack of studies** that assessed whether one modality of ventilation is better than others.
- and mostly in traumatic brain injury (TBI), which show that patients ventilated in **pressure-regulated volume control mode (PRVC)** present less fluctuation in ICP and $PaCO_2$.
- The use of **positive end expiratory pressure (PEEP)** **is a cornerstone** in the

-management of respiratory failure and

-protective ventilation strategies **to prevent** atelectasis and optimize oxygenation.

- Its (PEEP) use **has been challenged** in brain injured patients
- as it can increase intrathoracic pressure and
- Reduce cerebral venous outflow
- however, PEEP seems to be safe as long as it does not cause hyperinflation and hemodynamic stability is maintained

- As consequence, **the European Society of Intensive Care Medicine (ESICM) consensus recommends**

-**that patients with brain injury without ARDS**

both without ICP elevation and with ICP elevation **(PEEP insensitive)**

should be ventilated with a PEEP level equal to patients without brain injury .

- **In patients with brain injury, with or without ARDS** and **without a raise in ICP**

-a lung protective mechanical ventilation strategy

-with low tidal volume and

-Low plateau pressure is strongly recommended to minimize respiratory complications.

- **whereas the question still remains regarding its use in patients with brain injury and unstable ICP** (Fig. 18.1)
- **in this latter situation**, ventilatory settings should be considered **case by case** and additional **neuromonitoring** is warranted to **assess cerebral metabolism**.

Oxygenation and Carbon Dioxide Targets

- **The blood levels of oxygen (PaO2) and CO2 should be strictly monitored, as both play pivotal roles in brain homeostasis.**
- **Peripheral oxygen saturation should be kept >94%** , both **hypoxemia** and **hyperoxemia** **should be avoided**
- **and PaO2** should be maintained **between 80 and 120 mmHg** regardless of ICP levels.
- **CO2 should be strictly and frequently assessed in brain injured patients**, as it can strongly **modify the cerebral perfusion** being **a major determinant** of cerebral blood flow (CBF) .
- As stated in the ESICM recommendation, the **optimal target** in brain injured patients without ICP elevation is **35–45 mmHg**.

Oxygenation and Carbon Dioxide Targets

- **Short-term hyperventilation** should be used only when

-Refractory ICP elevation and

-signs of brain herniation are present .

- **In such cases**, a target of **PaCO2 = 30 mmHg** is warranted, and the possible effects on brain perfusion should be strictly monitored .
- Figure 18.2 shows a decisional tree proposed by the authors for the management of ventilatory support in acute brain injury patients.

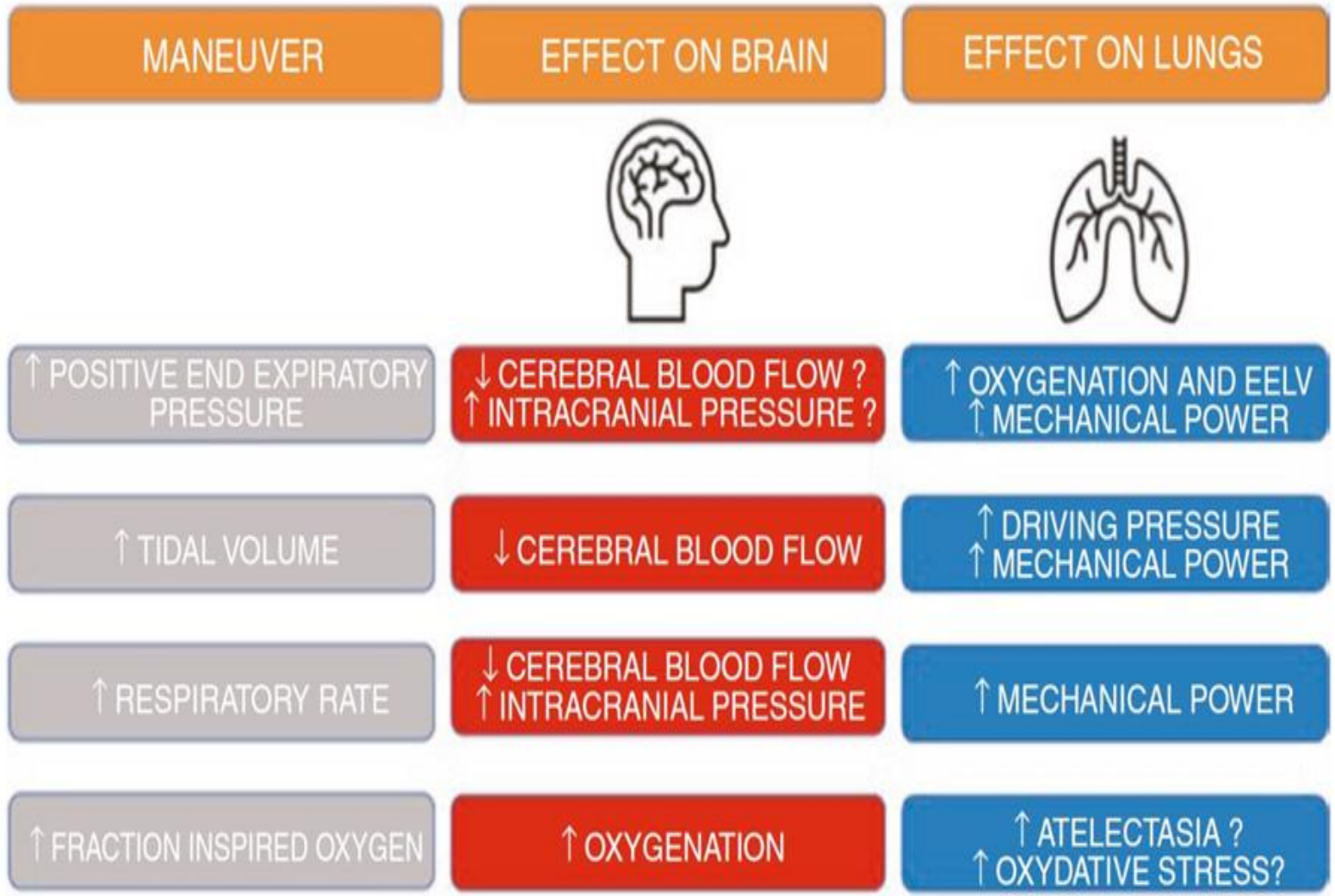


Fig. 18.1 Effects of ventilatory parameters on brain and lungs. *EELV* end-expiratory lung volume

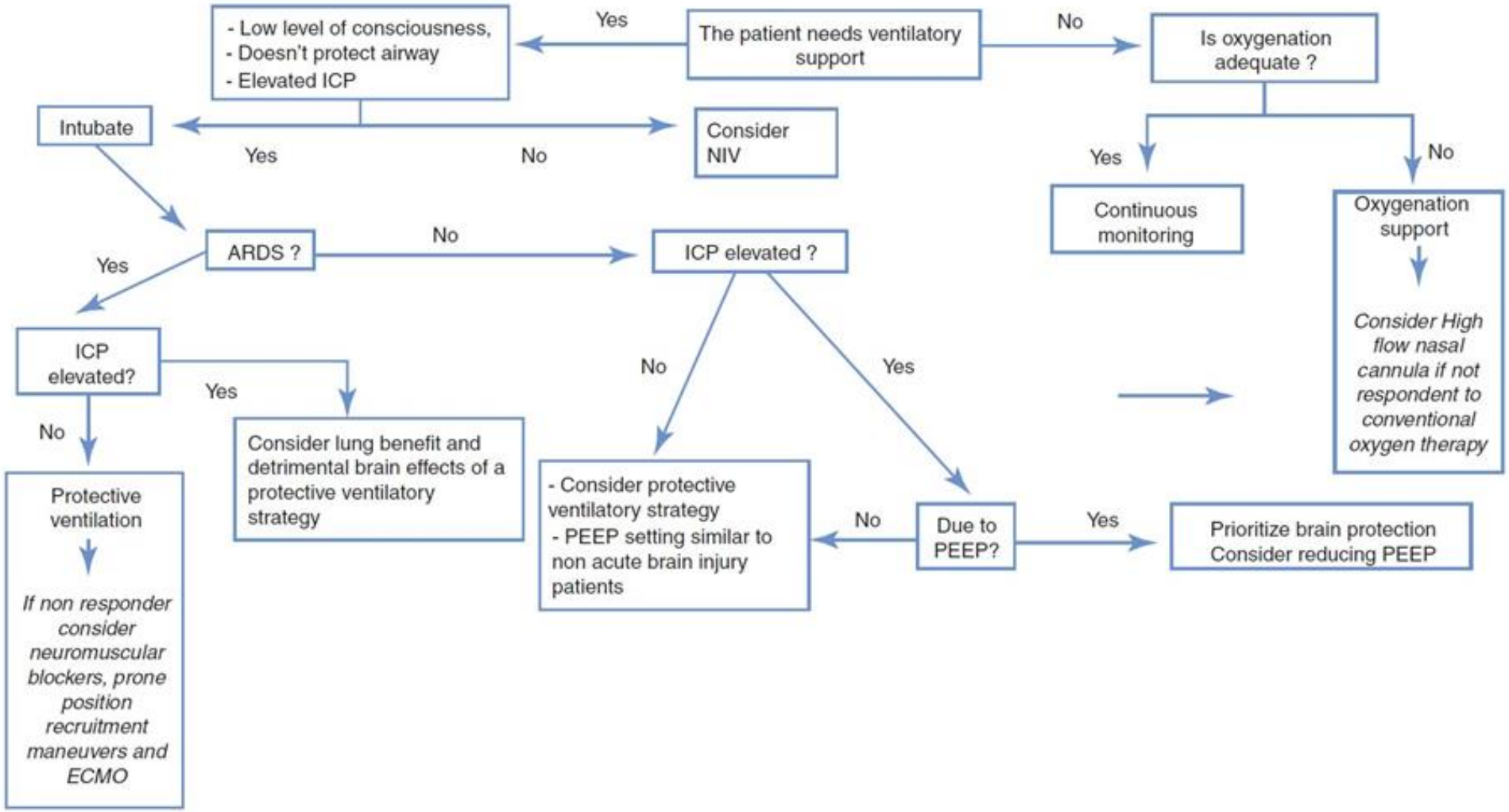


Fig. 18.2 Possible algorithm of ventilatory management in brain injured patients. *ICP* intracranial pressure, *NIV* non-invasive ventilation, *ARDS* acute respiratory distress syndrome, *ECMO* extracorporeal membrane oxygenation, *PEEP* positive end-expiratory pressure

Intracranial Pressure Monitoring and Management

A 30-year-old male with head injury was on a ventilator. He was withdrawing from painful stimulus. His pupillary responses were equal and brain CT scan showed bilateral frontal contusion and subarachnoid hemorrhage . His blood pressure (BP) was 100/60 mmHg, and SpO_2 was 93% on 0.6 FiO_2. His temperature was 100 °F and blood sugar was 70 mg/dL. He had been nursed with the head elevated at 45°.

- **Increased intracranial pressure (ICP)** should be suspected in all patients with altered mental state, especially due to an **intracranial pathology**.
- **Normal ICP is below 15 mmHg**.
- **Intracranial hypertension (ICH) is defined as pressures ≥20 mmHg.**
- Prompt assessment and management of this problem **prevents secondary brain injury.**
- **Successful treatment of patients with elevated high ICP**

1.Needs quick recognition

2-the appropriate use of invasive monitoring

3-and treatment directed at both decreasing ICP and reversing its etiological cause.

1.Initiate Resuscitation

- If elevated **ICP is suspected**, care should be taken to minimize its rise during **intubation** through **careful positioning** and **adequate sedation**.
- **Avoid hypercapnia as it raises ICP by causing vasodilation**.
- **Avoid succinylcholine during intubation as it may increase ICP**.
- **Pretreat with mannitol if pupils are unequal**.
- **Large shifts in blood pressure should be minimized, with particular care taken to avoid hypotension.**

Hypotension, especially in conjunction with hypoxemia, can induce reactive vasodilation and elevations in ICP.

- ` **Vasopressors** have been shown to **be safe** in **most patients with intracranial hypertension** and **may be required** to maintain cerebral perfusion pressure (CPP) of more than **50 mmHg**.

2.Recognize Features of Increased ICP

- **Raised ICP** may present with **symptoms of**

1.Headache

2.altered level of consciousness,

3.weakness of extremities, or as respiratory arrest.

Careful clinical examination would reveal one or more of the following nonspecific signs.

Frequent neurological examination is essential as these patients **may deteriorate suddenly.**

- **Cranial nerve VI palsies, papilledema**
- **Dilatation of ipsilateral or contralateral pupil**
- **Ptosis**
- **Hemiparesis**
- **Alteration of respiration**
- **Spontaneous periorbital bruising**
- **Decerebrate posturing**
- **Cushings triad (bradycardia, respiratory depression, and hypertension)**

3. Urgently Manage Increased ICP

- **Urgent measures** may need to be instituted prior to a more detailed workup **(e.g., imaging or ICP monitoring)** in a patient who presents **acutely** with **history or examination findings** suggestive of elevated ICP.
- Many of these situations will rely **on clinical judgment**, but the following combination of findings suggests the need for **urgent intervention:**

❖ **A Glasgow Coma Scale (GCS) ≤8 in the absence of other systemic problems** such as severe hypoxia, hypercapnia, hypotension, hypoglycemia, hypothermia, or intoxication to explain the mental state.

❖**In such patients**

Osmotic diuretics should be used urgently, **10–20% intravenous**

-mannitol (1–1.5 g/kg)

-Head elevation to 30–45°

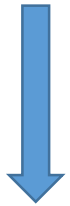
-Hyperventilation to a PCO2 of 26–30 mmHg

• In addition, **standard resuscitation** techniques should be instituted as soon as possible.

• Prolonged hyperventilation is **contraindicated** in the setting of

1.traumatic brain injury

2.and acute stroke



as hypocapnia and **respiratory alkalosis will cause cerebral vasoconstriction and worsen perfusion.**

• **Ventriculostomy** is a rapid means of simultaneously **diagnosing** (by measuring intraventricular pressure) and **treating elevated ICP**.

4.Identify Causes of Raised ICP (Table 33.1)

- Brain is enclosed in a closed compartment formed of bony skull.
- **It consists of three essential elements**:

1.brain matter (noncompressible: 80%)

2.CSF: 10%, and

3.blood (arteries and veins): 10%.

- **Increase in any one of the elements will displace the others to keep ICP constant** till a point when there will be an exponential rise of ICP.
- Displacement of brain will cause herniation syndromes.
- This **interrelationship** is known as **(Monroe Kellie doctrine)**

Table 33.1 Common reasons for raised intracranial lesions

1. Localized mass lesions
• Traumatic hematomas (extradural, subdural, and intracerebral)
• Abscess
• Neoplasms
• ICH and massive cerebral infarction
• Ruptured aneurysm
• Diffuse axonal injury
2. Impaired CSF circulation
• Obstructive and communicating hydrocephalus
3. Obstruction to venous outflow
• Cerebral venous thrombosis
• Depressed fractures overlying major venous sinuses
4. Diffuse brain edema
• Infections and inflammations (encephalitis, meningitis, vasculitis)
• Diffuse head injury
• Hepatic encephalopathy
• Hypertensive encephalopathy
• Water intoxication
• Near-drowning
• Idiopathic intracranial hypertension (Pseudotumor cerebri)

Start Specific Management of Increased ICP

- **Intracranial hypertension (ICH) is a medical emergency**.
- **The best therapy for ICH** is **resolution of the proximate cause of elevated ICP.**
- Examples include

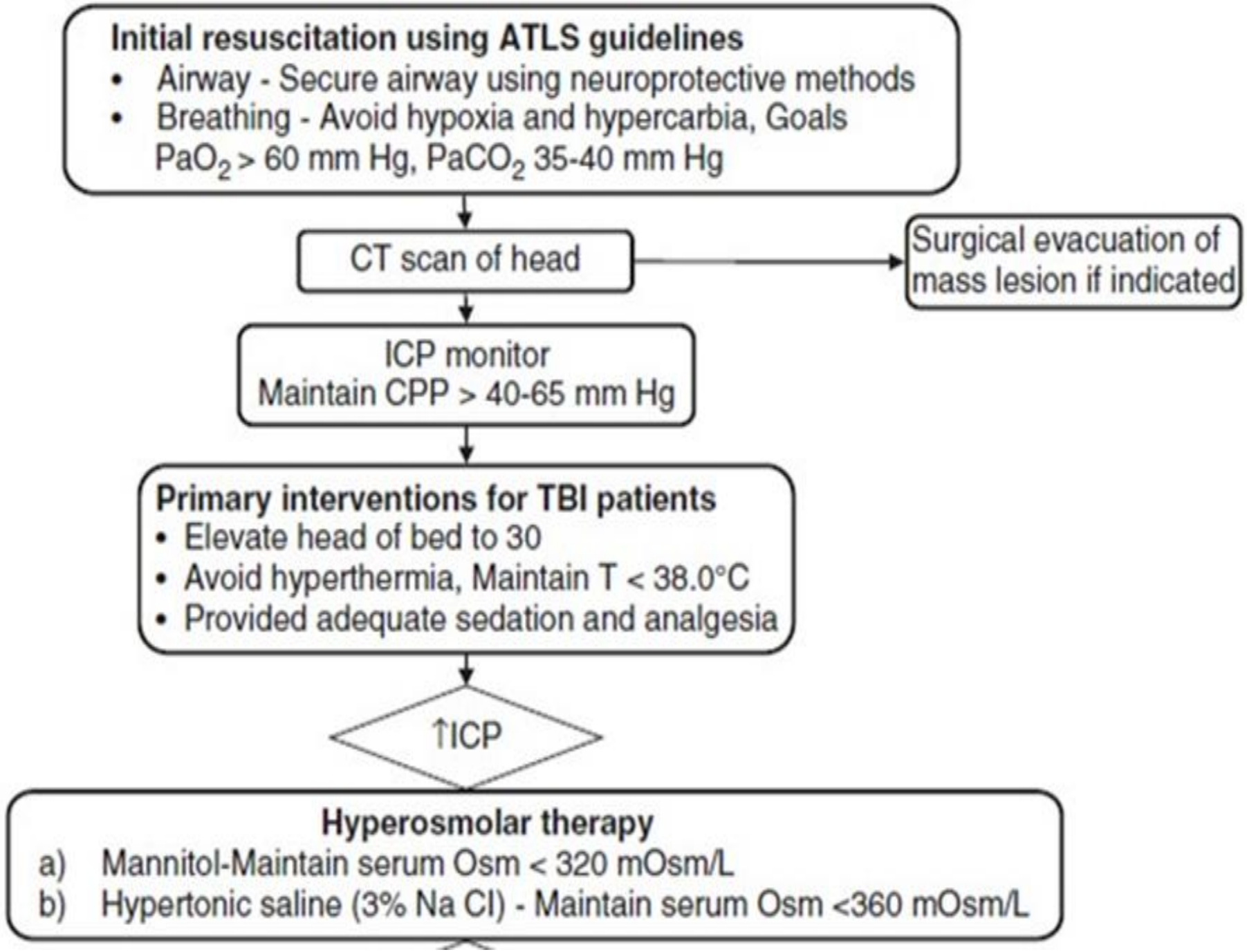
1.the evacuation of a blood clot

2.Resection of a tumor

3.CSF diversion in the setting of hydrocephalus or

4.treatment of an underlying metabolic disorder.

- **Measures to lower ICP are generally applicable to all patients with suspected ICH.**
- Some measures **(particularly glucocorticoids)** are reserved for specific causes of ICH.


Initial resuscitation using ATLS guidelines
• Airway - Secure airway using neuroprotective methods
• Breathing - Avoid hypoxia and hypercarbia, Goals PaO_2 > 60 mm Hg, $PaCO_2$ 35-40 mm Hg
CT scan of head
Surgical evacuation of mass lesion if indicated
ICP monitor
Maintain CPP > 40-65 mm Hg
Primary interventions for TBI patients
• Elevate head of bed to 30
• Avoid hyperthermia, Maintain T < 38.0°C
• Provided adequate sedation and analgesia
↑ICP
Hyperosmolar therapy
a) Mannitol-Maintain serum Osm < 320 mOsm/L
b) Hypertonic saline (3% Na Cl) - Maintain serum Osm <360 mOsm/L

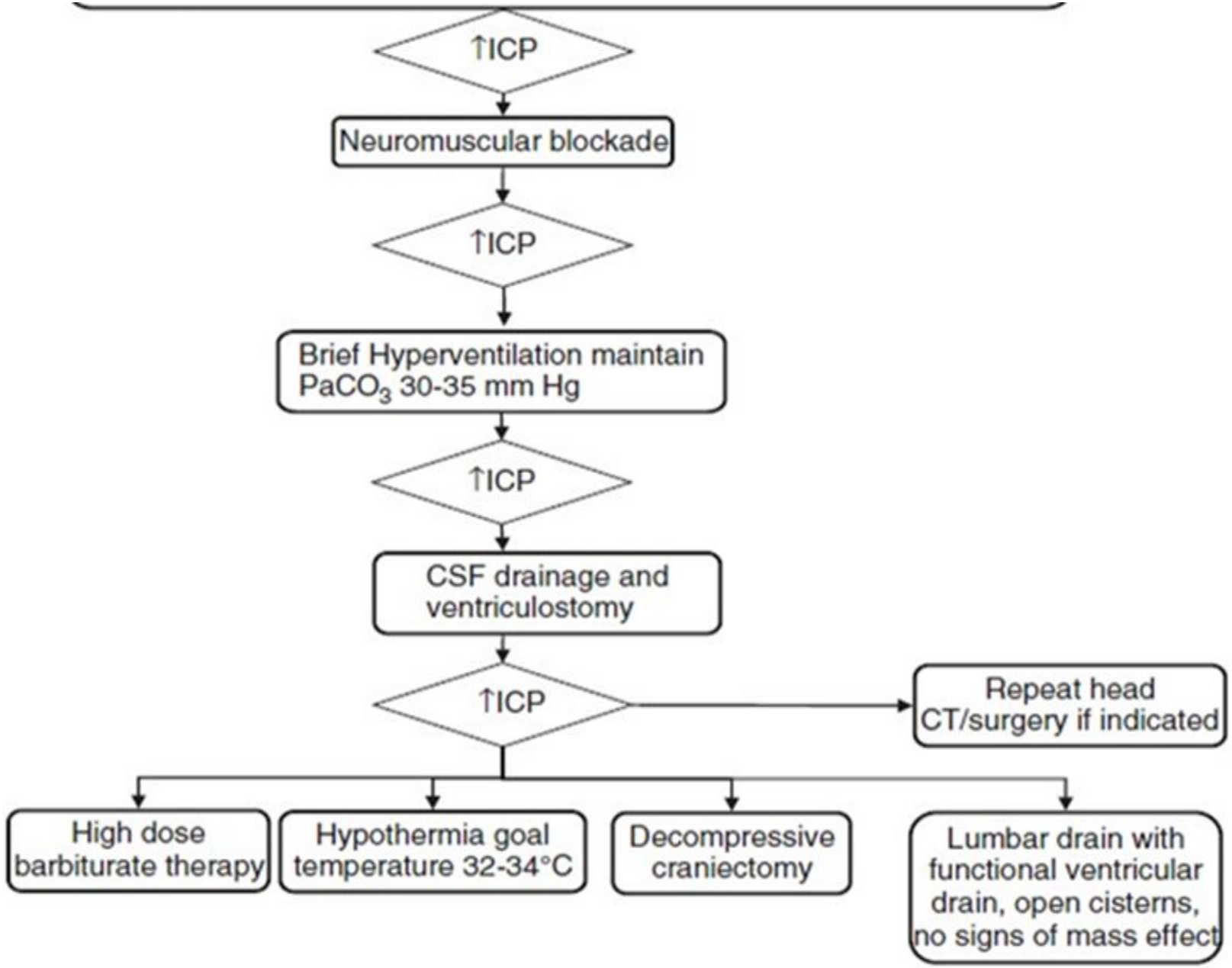


Fig. 33.3 Raised ICP Management

Mannitol

- **Osmotic diuretics** reduce the brain volume by drawing free water out of the tissue and into the circulation, where it is excreted by the kidneys, thus dehydrating brain parenchyma.
- **The most commonly used agent is 20% solution of mannitol** given as a **bolus of 1 g/kg**.
- Repeated dosing can be given at **0.25–0.5 g/kg** as needed, generally every **6–8 h.**
- Use of any osmotic agent should be carefully evaluated in patients with renal and cardiac insufficiency.
- **Useful parameters to monitor** in the setting of **mannitol therapy** include 1.**serum sodium**,

2.serum osmolality,

3. and renal function.

- **Concerned findings** associated with the use of **mannitol** include

1.serum sodium of more than 150 mEq

2.serum osmolality of more than 320 mOsm

3.or rising blood, urea, and creatinine suggestive of evolving acute tubular necrosis (ATN).

- **Mannitol can lower systemic BP, necessitating careful use** if associated with **a fall in CPP.**
- **It can cause massive diuresis** and **loss of**

1.Potassium

2.magnesium

3.And phosphorus.

- **In patients on mannitol therapy, euvolemia** should be maintained by

1.Replacing volume loss with normal saline and

2.additive electrolytes.

Loop Diuretics

• **Furosemide**, **0.5–1.0 mg/kg intravenously**, may be given with **mannitol** to potentiate its effect. However, this effect can **also exacerbate 1.dehydration and**

2.hypokalemia.

Hypertonic Saline

• Hypertonic saline in bolus doses **may acutely lower ICP**.

• **Advantages of hypertonic saline are**

1.its use in **hypotensive patients**,

2.Reduced potential to cause **renal damage**

3.and **less hyponatremia**.

• The volume and tonicity of saline (3–23.4%) used in these reports have varied widely.

• Use of the central line is recommended for **23% saline** to prevent **venous thrombosis**.

- In patients **without central venous access**, **continuous infusion of hypertonic saline (1.25–3%)** may help to keep serum osmolality elevated.
- **Target the serum sodium level** of **150–160 mEq/L.**
- **Weaning from osmotherapy (**should be gentle)

_**as sharp decrease** in serum sodium may cause **cerebral edema**.

- **Every day, 5–8 mEq decrease** in **serum sodium** is generally recommended.

Glucocorticoids

- In general, glucocorticoids are **not considered** to be useful in the management of increased ICP **due to** cerebral infarction or intracranial hemorrhage.
- **In contrast, glucocorticoids** may have a role in the setting of intracranial hypertension **caused by**

1.brain tumors

2.and CNS infections.

Hyperventilation

- The use of **mechanical ventilation to lower** $PaCO_2$ to 26–30 mmHg has been shown to rapidly reduce ICP through

1.vasoconstriction

2.And a decrease in the volume of intracranial blood.

- The effect of **hyperventilation** on **ICP is short-lived (1–24 h).**
- Therapeutic hyperventilation may be considered as an **urgent intervention** when

1.Elevated ICP complicates cerebral edema

2.Intracranial hemorrhage and

3.Tumor.

- Hyperventilation should **not be** used on **a chronic basis**, regardless of the cause of ICH.

- **Hyperventilation should be minimized**

1. in patients with traumatic brain injury

2. Or in patients with acute stroke.

- In these settings, **vasoconstriction** may cause a critical decrease in local cerebral perfusion and worsen neurological injury, **particularly in the first 24-48 h**.

- This might be used as a **temporizing measure** for patients **awaiting a definitive therapy** like surgical evacuation of a cerebral clot or tumor.

- **Barbiturates**
- The use of barbiturates is predicated on their ability to **reduce brain metabolism and cerebral blood flow**, thus **lowering ICP** and exerting a **neuroprotective effect**.
- However, the therapeutic value of this remains **unclear**.
- **Pentobarbital** is generally used, with **a loading dose of 5–20 mg/kg** as a bolus, **followed by 1–4 mg/kg/h**.
- **Treatment should be assessed based on**

1.ICP

2.CPP

3.and the presence of unacceptable side effects.

- Continuous electroencephalogram **(EEG)** monitoring is generally recommended with **EEG burst suppression** as an indication of **maximal dosing.**

Therapeutic Hypothermia

- It is **not currently recommended** as a standard treatment for increased intracranial pressure.
- **Neuromuscular Paralysis**
- This should generally be **avoided** unless the patient has refractory rise of ICP and is being closely monitored.

Removal of CSF

- When hydrocephalus is identified, **a ventriculostomy should be inserted**.
- **Rapid aspiration of CSF** should be avoided because it may lead to obstruction of the catheter opening by brain tissue.
- In patients with aneurysmal subarachnoid hemorrhage, **abrupt lowering of the pressure** differential across the aneurysm dome can precipitate recurrent hemorrhage.
- CSF should be removed at a rate of approximately 1–2 mL/min, for 2–3 min at a time, with intervals of 2–3 min in between.
- This should be done till **a satisfactory ICP** has been achieved (ICP < 20 mmHg) or till CSF is no longer easily obtained.

- Slow removal can also be accomplished by

1.passive gravitational drainage through the ventriculostomy,

2.and bag is positioned raised at the desired level of intracranial pressure.

- **A lumbar drain is generally not recommended** in the setting of high ICP **due to the risk of transtentorial herniation**.

Decompressive Craniectomy

- **Decompressive craniectomy** removes the rigid confines of the bony skull, increasing the potential volume of the intracranial contents.
- It has been demonstrated that in patients with **elevated ICP**, **craniectomy alone lowers ICP up to 15%.**
- **Opening the dura** in addition to the bony skull results in an average **decrease in ICP of 70%.**
- A recent study (DECRA) has shown the worse 6-month qualitative outcome with this procedure in the **severe traumatic brain injury patient**.

Weaning and Tracheostomy

- **The burden of delayed extubation and extubation failure is high in acute brain injury patients,**

1.leading to prolonged time of mechanical ventilation

2.and ICU length of stay,

3.and high mortality rates .

- **The decision to extubate and/or wean a patient from ventilatory support after acute brain injury** should be **and guided by several neurological and non-neurological factors such as**

1.the expected clinical trajectory of the patients

2.the expected complications of the underlying acute brain injury process

3.the level of consciousness

4.and the ability of the patient to protect airway (adequate cough, gag, and swallowing reflexes) .

-Patients should also have

5.a stable hemodynamic and

6.Stable metabolic status

7.have adequate oxygenation and pulmonary function.

- A spontaneous breathing test is usually recommended for the ICU population who stayed mechanically ventilated for >24 h .
- Patients who have

1.persistently reduced the level of consciousness

2.and those who fail one or more extubation attempts should be

tracheostomized to facilitate **weaning and respiratory care**.

- The appropriate timing to perform a tracheostomy is still unknown, but in acute brain injury patients, **early tracheostomy** may reduce ICU and hospital length of stay .


Thank
you