Chapter 10
Hydrocephalus Management in the ICU

10.1 Introduction

Hydrocephalus is characterized by the abnormal accumulation of cerebrospinal fluid (CSF) within the brain's ventricles, leading to increased intracranial pressure (ICP). This condition can arise from various etiologies, including congenital malformations, infections, hemorrhage, tumors, and idiopathic causes. Effective management in the ICU requires a multidisciplinary approach encompassing clinical evaluation, neuroimaging, intracranial pressure monitoring, medical and surgical interventions, and rigorous postoperative care [1, 2].

A critical aspect of hydrocephalus management is differentiating between idiopathic normal pressure hydrocephalus (iNPH) and other forms such as secondary NPH and obstructive hydrocephalus. This distinction guides specific management decisions, including the consideration of shunting or surgical options. (Ref. Algorithm 10.1).

1. **Initial Assessment**

Clinical Evaluation

- Symptoms Indicative of Elevated ICP: Common symptoms include headache, nausea, vomiting, altered consciousness, and papilledema.
- Gait Disturbance: A hallmark feature of iNPH. Assess using specific tests like the iNPH grading scale and the Timed Up and Go (TUG) test to quantify gait impairment.
- Cognitive and Urinary Symptoms: Evaluate for cognitive decline and urinary incontinence, which, along with gait disturbance, constitute the classic triad of iNPH.
- Focal Neurological Deficits: Assess motor and sensory deficits to determine the extent and impact of hydrocephalus.

S. B. Mishra et al., *Mastering ICU Care*,
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Neuroimaging
Computed Tomography (CT) and Magnetic Resonance Imaging (MRI):

- Confirm Diagnosis: Identify ventricular enlargement and assess the extent of hydrocephalus.

Differentiate Types:

- Communicating vs. Noncommunicating Hydrocephalus: Determine if CSF flow is obstructed within the ventricular system.

Idiopathic Normal Pressure Hydrocephalus (iNPH):

- Disproportionately Enlarged Subarachnoid Space Hydrocephalus (DESH): Look for ventricular enlargement with disproportionately enlarged subarachnoid spaces.
- Evans Index: Calculate the ratio of the maximum width of the frontal horns to the maximum internal diameter of the skull (>0.3 suggests ventricular enlargement).
- Flow Void Signs: Identify hyperintensities in CSF flow areas on MRI indicative of altered dynamics.

Intracranial Pressure Monitoring
Consider ICP Monitoring:

- Indications: Suspected cases of elevated ICP or when clinical symptoms do not correlate with imaging findings.

External Ventricular Drain (EVD) Placement:

- Purpose: Monitor ICP and allow for therapeutic CSF drainage.

CSF Dynamics Investigation:

- Infusion Studies: Measure CSF outflow resistance and compliance.
- Tap Tests: Remove a volume of CSF to assess symptom improvement, particularly useful in diagnosing iNPH.

2. **Management Pathway**

Decision Point: Elevated ICP
If ICP is Elevated:

- Initiate medical management to reduce ICP.
- Consider CSF diversion procedures if ICP remains persistently elevated.

If ICP is Not Elevated:

- Continue monitoring the patient.
- Reassess if symptoms progress or new signs develop.

3. **Medical Management**

Osmotherapy
- Mannitol or Hypertonic Saline: Administered to reduce ICP through osmotic diuresis.

Acetazolamide
- Mechanism: Decreases CSF production by inhibiting carbonic anhydrase.

Maintaining Cerebral Perfusion Pressure (CPP)
- Blood Pressure and Fluid Management: Ensure adequate CPP and oxygen delivery to the brain.

Sedation and Analgesia
- Purpose: Reduce metabolic demand and control agitation to prevent further increases in ICP.

4. **Persistently Elevated ICP**

- Intervention: Proceed to CSF diversion procedures if ICP remains elevated despite medical management.

5. **CSF Diversion Procedures**

External Ventricular Drainage (EVD)
- Indications: Acute management and temporary CSF drainage.
- Management: Adjust drainage based on ICP readings and clinical status.
- Monitoring: Vigilant for complications such as infection or hemorrhage.

Ventriculoperitoneal (VP) Shunt
- Indications: Chronic or recurrent hydrocephalus, especially in communicating hydrocephalus and iNPH.

Shunt Management Considerations:

- Programmable Valves: Recommended for optimizing CSF drainage and allowing noninvasive postoperative adjustments.
- Overdrainage Prevention: Use anti-siphon devices or gravitational units to prevent complications like subdural hematomas.

Surgical Interventions
Endoscopic Third Ventriculostomy (ETV):

- Suitable for: Patients with obstructive hydrocephalus (e.g., aqueductal stenosis).
- Procedure: Create an opening in the floor of the third ventricle to divert CSF flow.

Cranioplasty:

- Purpose: Restore normal cranial anatomy and improve CSF dynamics after craniectomy.

6. **Postoperative Care**

Monitoring for Complications
- Infection: Watch for signs of meningitis or ventriculitis.

- Shunt Malfunction: Assess for recurrence of hydrocephalus symptoms, indicating possible obstruction or disconnection.
- Overdrainage: Monitor for headaches, nausea, or subdural hematomas due to excessive CSF drainage.

Regular Follow-Up Imaging
Serial Neuroimaging:

- Assess: Ventricular size, shunt position, and detect any new lesions or complications.

Adjust Shunt Settings
Programmable Valve Adjustments:

- Optimize CSF Drainage: Based on clinical response and imaging findings.
- Noninvasive Adjustments: Allow individualized patient management without additional surgeries.

Long-Term Follow-Up
Clinical Assessments:

- Neurological Status: Monitor gait, cognition, and urinary function using standardized scales like the iNPH grading scale.

Interdisciplinary Approach:

- Collaboration: Neurosurgeons, neurologists, physiotherapists, and rehabilitation specialists.

Complication Management:

- Prompt Intervention: Address shunt infections, obstructions, and mechanical failures swiftly.

7. **Advanced Monitoring and Management**

CSF Dynamics Studies
- Infusion Studies: Evaluate CSF outflow resistance to assess absorption capacity.
- Pressure-Volume Index (PVI): Determine brain compliance and compensatory reserve.
- Resistance-Area Product (RAP) Index: Analyze the relationship between ICP amplitude and mean ICP to assess intracranial compliance.
- B-Waves Analysis: Identify ICP waveform patterns indicative of impaired CSF dynamics.

Management of Associated Conditions
- Underlying Etiologies: Treat conditions such as subarachnoid hemorrhage (SAH), traumatic brain injury (TBI), or infections contributing to hydrocephalus.
- Rehabilitation Services: Provide physical therapy for gait disturbance and occupational therapy for cognitive deficits.

Interdisciplinary Approach
- Collaborative Care.
- Team Meetings: Regularly review and update the treatment plan based on patient responses.
- Family Involvement: Educate and involve caregivers in decision-making processes.

10.1.1 Interpretation of CSF Dynamics Studies and Appropriate Interventions

Normal CSF Dynamics
Parameters:

- CSF Outflow Resistance (R): 13–18 $mmHg \cdot ml^{-1} \cdot min^{-1}$
- Pressure-Volume Index (PVI): >26 ml
- Elasticity (E): <0.18 ml^{-1}
- RAP Index: <0.6
- B-Waves: Minimal or absent
- Interpretation: No significant obstruction or impaired absorption.
- Intervention: Routine monitoring and supportive care; no immediate CSF diversion required.

Increased CSF Outflow Resistance
Parameters:

- R: >18 $mmHg \cdot ml^{-1} \cdot min^{-1}$
- PVI: <13 ml
- E: >0.18 ml^{-1}
- RAP Index: ≈1
- B-Waves: Frequent and high amplitude
- Interpretation: Impaired CSF absorption or obstruction with poor compensatory reserve.
- Intervention: Surgical CSF diversion via VP shunt or ETV; close ICP monitoring and treatment adjustments.

Communicating Hydrocephalus
Parameters:

- Increased R, variable PVI, increased E, RAP Index ≈1, significant B-Waves.
- Interpretation: Impaired absorption at arachnoid granulations or other CSF pathways.
- Intervention: Long-term CSF diversion strategies like VP shunt placement; perform lumbar drainage or tap tests to assess symptom improvement before permanent shunting.

Obstructive Hydrocephalus
Parameters:

- Markedly increased R, low PVI, high E, high RAP Index, significant B-Waves.
- Interpretation: Blockage of CSF pathways (e.g., aqueductal stenosis).
- Intervention: Immediate surgical intervention (ETV or shunt placement) to relieve obstruction.

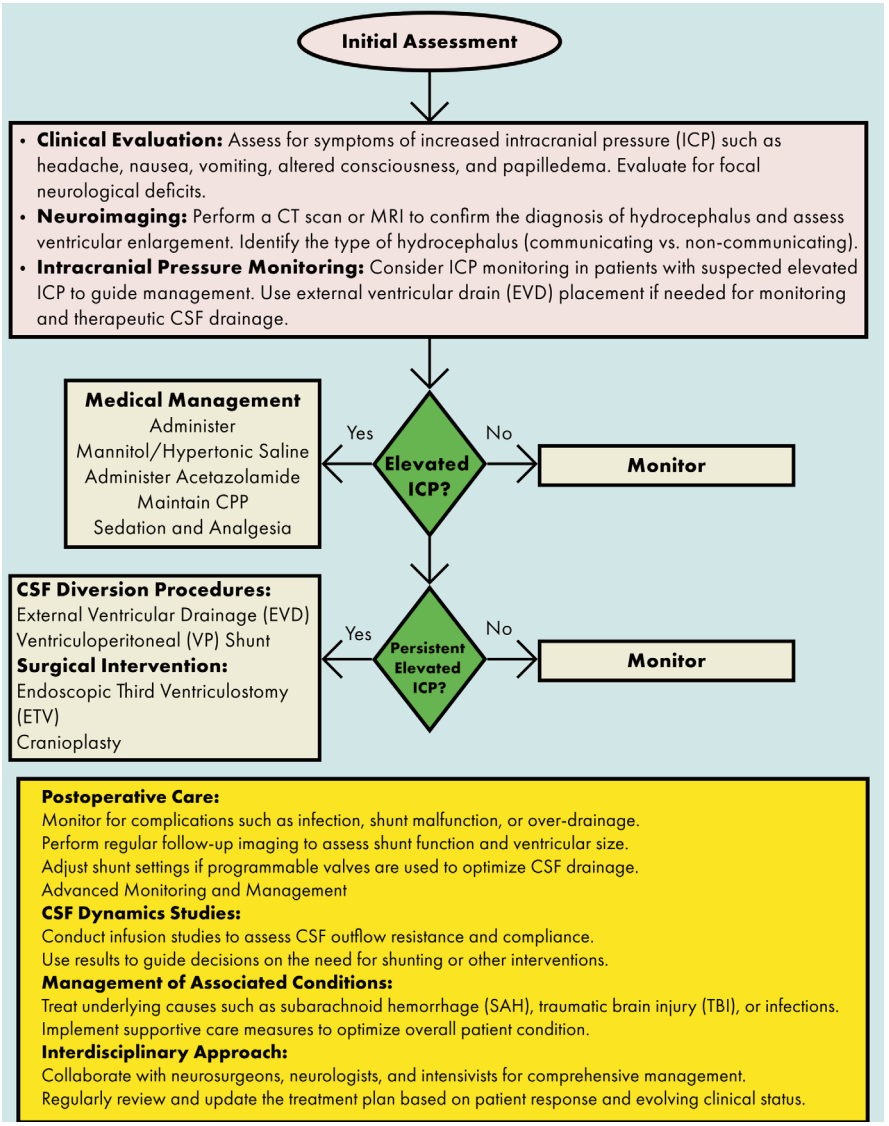
Brain Atrophy with Normal CSF Dynamics
Parameters:

- Low R, high PVI, low E, RAP Index <0.6, minimal or absent B-Waves.
- Interpretation: Normal CSF dynamics with evidence of brain atrophy; no significant hydrocephalus.
- Intervention: CSF diversion not required; focus on managing underlying conditions causing atrophy.

10.2 Conclusion

Management of hydrocephalus in the ICU is complex and requires careful assessment, timely intervention, and ongoing monitoring. Differentiating between types of hydrocephalus, particularly iNPH, is essential for tailoring management strategies. Incorporating advanced diagnostic tools like CSF dynamics studies and specific neuroimaging features enhances diagnostic precision. Postoperative care with long-term follow-up ensures optimal outcomes by promptly addressing complications and adjusting treatments as necessary. A structured, interdisciplinary approach enables clinicians to provide comprehensive care for patients with this challenging conditions.

Algorithm 10.1: Hydrocephalus management in the ICU



Bibliography

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