Increased Intracranial Pressure

Definition / Supporting Information

Increased intracranial pressure (ICP) is a potentially life-threatening neurological or neurosurgical emergency. ICP may be chronic (eg, idiopathic intracranial hypertension (IIH)) or acute (eg, following head injury).

Keywords / also known as: pressure around the brain, raised intracranial pressure

Essential History

Evaluation should progress only after the ABCs (airway, breathing, and circulation) of resuscitation have been addressed.

Ask about:

- Timing and evolution of symptoms
- Head trauma
- Family history of arteriovenous malformation
- Medications, eg,
  - Corticosteroids (increased intracranial pressure occurs more commonly on withdrawal of these)
  - Recombinant growth hormone (somatropin)
  - Levothyroxine
  - Certain antibiotics, eg, tetracyclines, nitrofurantoin, ciprofloxacin
  - Ciclosporin
  - Vitamin A (retinol) in infants / isotretinoin
- Known endocrine conditions
  - Adrenal insufficiency
  - Cushing's disease
  - Hypoparathyroidism
  - Hypothyroidism
  - Excessive thyroxine replacement
  - Known chronic kidney disease

'Red Flag' Symptoms and Signs

Evaluation should progress only after the ABCs (airway, breathing, and circulation) of resuscitation have been addressed.

Ask about:

- Irritability
- Seizures
- Unsteadiness / loss of balance
- Headache
  - Persistent, recurrent or severe
  - May wake the young person up, or occur particularly when they wake up
- Vomiting
  - Persistent or recurrent
- Visual changes / abnormal eye movements
- Abnormal head position
  - Especially preschool children
- Behavioural changes
- Poor feeding
- Developmental delay
- Delayed or arrested puberty

Look for:

- Cushing's triad
  - Irregular pattern of breathing
  - Hypertension
  - Bradycardia
- Decerebrate or decorticate posture
- Rapidly deteriorating mental status
- Parinaud's sign (up-gaze paresis)
- Focal neurological deficits
- Pupillary abnormalities
- Papilloedema
- Cranial neuropathy (eg, sixth cranial nerve palsy; chronic increased ICP)
- Split sutures (especially lambdoid)
- Bulging fontanelle
- Altered mental status
- Increased head circumference
- Apparent developmental arrest or regression

Differential Diagnosis / Conditions

- Head trauma
  - Cerebral oedema
  - Intracerebral haemorrhage

  - Extracerebral haemorrhage
    - Subdural
    - Epidural
- Vascular causes
  - Arterial or venous infarctions
  - Intracerebral haemorrhage
  - Dural sinus thrombosis
  - Subarachnoid haemorrhage
  - Vascular anomalies
    - Vein of Galen malformation
    - Arteriovenous malformations
- Neoplastic causes
  - Primary brain tumours
  - Metastatic (intracerebral, meningeal infiltration)
- Hydrocephalus
  - Congenital or acquired
  - Communicating or non-communicating
- Idiopathic intracranial hypertension
- Central nervous system infections
  - Meningitis
    - Bacterial
    - Fungal
    - Mycobacterial
  - Encephalitis
    - Focal
    - Diffuse
  - Abscess
- Metabolic causes
  - Inborn errors of metabolism (hyperammonaemia)
  - Hepatic encephalopathy
  - Diabetic ketoacidosis
  - Acute kidney injury / chronic kidney disease
  - Reye’s syndrome
  - Hypoxic–ischaemic encephalopathy
  - Fluid–electrolyte abnormalities
    - Hyponatraemia
    - Hypernatraemia
- Structural causes
  - Craniosynostosis
  - Status epilepticus

Investigations

Evaluation should progress only after the ABCs (airway, breathing, and circulation) of resuscitation have been addressed.

To be undertaken by specialist practitioners (eg, Emergency Department / General Paediatric Team(s)):

- Computed tomography (CT) or magnetic resonance imaging (MRI)
  - MRI provides better anatomical differentiation than CT, but may be unavailable in the emergency setting
  - If a mass lesion is suspected, neuroimaging (regardless of modality) should include contrast enhancement
- Ultrasonography in infants may show ventriculomegaly that would trigger further imaging (CT or MRI)
- Magnetic resonance venography:
  - Is recommended for suspected dural venous sinus thrombosis
  - May show extraluminal narrowing of the transverse sinus that may be a typical feature of IIH
- Lumbar puncture (LP)
  - Measure cerebrospinal fluid (CSF) pressure
    - Between 12 and 18 cm is normal
    - If a mass lesion is suspected, neuroimaging is generally recommended before LP, as withdrawing lumbar CSF may create a pressure gradient intracranially and precipitate herniation syndrome
    - Spinal fluid analysis should always include glucose and protein measurement and a total and differential cell count
    - Depending on the clinical situation, other studies can be obtained, including microbial cultures, special stains, and cytology

Treatment Approach

Emergency management (ABC) to be undertaken by non-specialist practitioners (eg, GP / ambulance teams) during initial assessment and stabilisation, while arranging emergency transfer to secondary care, is detailed in the initial paragraph below; working seamlessly with specialist practitioners (eg, Emergency Department / Paediatric Team(s)):

- Assess airway, breathing, and circulation (ABC)
- When acute increased ICP is suspected:
  - Stabilise the airway
    - In most instances, this will require rapid, controlled intubation (when available)

  - Obtain intravenous (IV) access where possible or appropriate
    - Use only isotonic solutions, minimising fluids initially unless circulatory compromise is evident
  - Measure the vital signs, and assess the neurological state rapidly and frequently
  - Position the head at 30 degrees, and maintain midline position if an injury to the cervical spine exists or is suspected
  - Maintain adequate intravascular volume and blood pressure
  - Maintain adequate oxygenation

To be undertaken by specialist practitioners (eg, Emergency Department / Paediatric Intensive Care / Paediatric Neurosurgery Team(s)):

- Monitor ICP, especially in traumatic brain injury
  - Maintaining normal ICP allows maintenance of cerebral perfusion pressure (CPP), oxygenation, and metabolic substrate delivery and prevents cerebral herniation
  - Remove CSF, aiming to keep ICP < 20 mm Hg and maintain CPP > 40 mm Hg
- Early hyperventilation of the patient with increased ICP decreases cerebral blood volume and ICP
  - The most rapid, effective way to decrease ICP acutely
  - This effect is transient; therefore, other methods must be used to maintain normal or near-normal ICP
- Intravenous osmotic agents (mannitol) do not permeate the blood–brain barrier
  - Mannitol is given rapidly in an initial IV bolus of 0.25–1.5 g/kg over 30-60 minutes
  - After administration, additional boluses 0.25–1.5 g/kg can be repeated once or twice after 4-8 hours, depending on the patient's status.
- IV boluses of hypertonic sodium chloride (2.7 or 3%) can reduce ICP and augment CPP for several hours
  - Initial dose 2-3 mL/kg over 20 minutes, preferably via central line
  - Continuous infusion of 3% sodium chloride between 0.1 and 1 mL/kg/h if needed
  - Administration on a sliding scale, with the minimal dose needed to maintain ICP under 20 mmHg
  - Serum osmolarity should be maintained below 360 mOsm/L when using hypertonic sodium chloride as the only hyperosmolar therapy to control brain oedema
- Rocuronium bromide, atracurium besilate, and vecuronium bromide can effectively decrease ICP by preventing manoeuvres that increase intrathoracic pressure, such as coughing, straining, or 'fighting' the ventilator

- Normothermia / normal body temperature should be maintained between 36°C and 37°C
  - Hypothermia decreases cerebral metabolism and may be considered in managing refractory increased ICP
  - Shivering should be prevented and efforts made to maintain full cardiorespiratory function
- Seizure activity (clinical or subclinical) places excessive metabolic demand on already compromised brain tissue
  - Diazepam (100 micrograms/kg/dose IV, or 300-400 micrograms/kg (max. 10 mg) if in status epilepticus)
  - Lorazepam (50-100 micrograms/kg/dose IV (max. 4 mg))
- Steroids have clear utility in managing oedema associated with:
  - Brain tumours
  - Refractory idiopathic intracranial hypertension
  - Dexamethasone is generally used
- Hyperglycaemia after head injury must be aggressively treated
  - This is associated with a poorer outcome than that for patients who are normoglycaemic
- Surgery may play a role:
  - In decreasing ICP in select patients with large intracerebral haemorrhages by removal of clot
  - In trauma patients with massive oedema and contusion
  - In patients who have a large cerebral infarction through craniectomy or decompression of the oedematous mass
  - In the latter two instances, surgery is performed after all other measures have failed and increased ICP becomes refractory

In neurologically stable patients with evidence of chronically increased ICP

- Evacuation of the chronic subdural haematoma
- Appropriate tumour management (corticosteroids, surgery or radiation plus chemotherapy or both)
- Treatment with acetazolamide, loop diuretics, steroids, or lumbar drain in patients with more benign causes of intracranial hypertension

Idiopathic intracranial hypertension

- LP is recommended to document opening CSF pressure and may be used therapeutically to decrease ICP by draining CSF
- Medical management includes carbonic anhydrase inhibitors (acetazolamide) to decrease CSF production
- Patients with severe symptoms or visual loss and those in whom standard medical therapy is failing may benefit from a short course of high-dose corticosteroids (prednisone)

- Patients in whom medical therapy fails or those experiencing progressive visual loss may be considered for surgical treatment that includes:
  - CSF shunting procedures (ventriculoperitoneal, ventriculoatrial, or lumboperitoneal shunt) **or**
  - Optic nerve sheath fenestration

When to Refer

Refer (arrange emergency transfer) to Paediatric Emergency or Intensive Care Team(s):

- Any child with any of the 'red flag' signs and symptoms

Refer urgently to specialist practitioners (eg, General Paediatric / Emergency Department / Paediatric Neurosurgical Team(s)) if:

- Macrocephaly or accelerating head growth (crossing percentiles)
- Persistent or recurrent headache or new onset of severe headache
- Persistent or recurrent vomiting or more than 2 weeks duration
- Mild papillo-oedema
- Visual abnormalities (field defects, diplopia)
- Developmental arrest or regression

Escalate care to Paediatric Intensive Care / Paediatric Neurosurgical Team(s) if:

- Bulging fontanelle
- Altered mental status
- Prolonged seizures
- New focal neurological deficits
- Moderate to severe papillo-oedema
- Cushing's triad

'Safety Netting' Advice

- Early identification and treatment before a catastrophic increase in ICP will improve outcome in selected children with mass lesions or treatable metabolic disorders
- Long term follow up will be necessary to check pressure and stabilisation. If there is any deterioration, urgent GP or specialist advice should be sought

Patient / Carer Information

Please note: whilst these resources have been developed to a high standard they may not be specific to children.

- Intracranial hypertension (Web page), the NHS website

Resources

National Clinical Guidance

Head injury: assessment and early management (Web page), NICE clinical guideline CG176, National Institute for Health and Care Excellence.

The brain pathways guideline: A guideline to assist healthcare professionals in the assessment of children who may have a brain tumour (PDF), Royal College of Paediatrics and Child Health.

The management of children and young people with an acute decrease in conscious level (PDF), Royal College of Paediatrics and Child Health.

Suggested Resources

Please note: these resources include links to external websites. These resources may not have national accreditation and therefore PCO UK cannot guarantee the accuracy of the content.

Headsmart; be brain tumour aware (Website), RCPCH, The Brain Tumour Charity, CBTRC, The University of Nottingham, The Health Foundation.

Head Injury (Web page - log-in required), Spotting the Sick Child

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