Practical Approach to Posttraumatic Intracranial Hypertension According to Pathophysiologic Reasoning

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KEYWORDS

• Intracranial pressure • Intracranial hypertension • Acute brain injury
• Cerebral perfusion pressure • Multimodal monitoring • Traumatic brain injury

KEY POINTS

- Intracranial hypertension (ICH) is major damage pathway of acute brain injury.
- ICH is a potentially life-threatening secondary brain insult.
- The causes of ICH are varied and multiple and, sometimes, the origin of ICH is outside the cranial cavity.
- Homeostasis of basic physiologic variables (physiologic neuroprotection) and avoiding secondary insults are important steps to control ICH.
- The correct management of ICH should be based on appropriate pathophysiologic analysis and multidisciplinary work.

Do what you can, with what you have, where you are

—Theodore Roosevelt

INTRODUCTION

An increase in intracranial pressure (ICP) can be a medical or surgical emergency.[1] Both intracranial and systemic events contribute to increased ICP after traumatic brain injury (TBI) and other acute or chronic neurologic conditions (ischemic stroke,

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subarachnoid hemorrhage, spontaneous intracerebral hemorrhage, tumors).[1,2] Intracranial hypertension (ICH) can be life threatening by mechanical or vascular effects. Mechanical effects are mediated through different types and degrees of cerebral displacement and herniation. Vascular effects result from reducing cerebral perfusion pressure (CPP), which is defined as mean arterial blood pressure (MABP) minus ICP. The CPP is the driving force of cerebral blood flow (CBF). As the CPP decreases, CBF may become insufficient for adequate brain-tissue perfusion and oxygenation.[3,4] The adequate level of CBF and CPP vary among patients and the optimal CPP value changes over time and is linked to cerebrovascular reactivity. Increased ICP and low CPP are associated with mortality and poor long-term outcome.[5–9]

DEFINITIONS

Normal ICP varies with age, body position, and clinical condition.[1,10] In healthy individuals in supine position it is between 7 and 15 mm Hg; while standing, it becomes negative with an average of about 10 mm Hg.[1,2,10] In term infants, 1.5 to 6 mm Hg is considered normal, whereas in children these values range between 3 and 7 mm Hg.[11] ICP can be increased transiently in physiologic situations such as a coughing or sneezing. Critically ill patients, occasional increases can be observed with changes in position, aspiration of secretions, asynchrony with mechanical ventilation, and physiotherapy.[1,2,5]

ICH is traditionally considered present in adults when ICP values are greater than 20 mm Hg for more than 5 to 10 minutes.[12,13] Initiating or intensifying treatment is generally indicated above this threshold. In other situations, such as decompressive craniectomy (DC) or contusions close to the midbrain (temporal, basal region of frontal lobes), it may be advisable to use a threshold of 15 mm Hg to start therapy.[14] However, the ICP threshold and the optimal time to initiate or intensify treatment are subjects of debate.[13–17] In addition, this threshold can change over time in individual patients. A recent review of the Brain Trauma Foundation guidelines suggests initiating treatment when ICP is greater than 22 mm Hg.[17]

BASIC PHYSIOLOGY

Unicompartment Model

Monro and Kellie[18] postulated that, in a rigid and inextensible structure such as the skull, ICP is the result of the sum of pressures exerted by each component of the cranial compartment. The components are parenchyma (70%), cerebrospinal fluid (CSF) (15%), and cerebral blood volume (CBV) contained in veins and arteries (15%).[18] This overall intracranial volume must remain constant. CSF and blood can act as a buffer, so they are displaced from the cranial compartment when a new volume is added.

ICP = Brain tissue (parenchyma) + CSF + CBV

Intracranial volumes

- Brain tissue
  Glia: 700 to 900 mL = 45.5%
  Neurons: 500 to 700 mL = 35.5%
- Blood: 100 to 150 mL = 7.5%
- CSF: 100 to 150 mL = 7.5%
- Extracellular fluids: 50 to 70 mL = 3.5%

From an anatomic point of view, the supratentorial space is responsible for 50% of the ICP, whereas the infratentorial is responsible for 30% and the spinal space comprises the remainder (20%).[2,15]