Intracranial Pressure Monitoring and Management of Intracranial Hypertension

Jon Perez-Barcena, MD, PhD[a,*],
Juan Antonio Llompart-Pou, MD, PhD[b], Kristine H. O'Phelan, MD[a]

KEYWORDS

- Intracranial pressure • Intracranial hypertension • Head injury

KEY POINTS

- Intracranial pressure is a reflection of the relationship between alterations in craniospinal volume and the ability of the craniospinal axis to accommodate the added volume.
- Intracranial pressure cannot be reliably estimated from any specific feature or CT finding and must be measured.
- Much information is available from ICP monitoring in addition to the measurement and display of absolute ICP.
- Elevated ICP is an important cause of secondary brain injury and is consistently associated with worse neurologic outcomes in patients with traumatic brain injury.
- ICP monitoring remains the cornerstone of management of patients with acute brain injury.

INTRODUCTION

The principles of intracranial pressure (ICP) were outlined by Monroe[1] and Kellie[2] in the 1820s. In essence, they noted that in adults, the brain is enclosed in a rigid case of bone and that the volume of its contents must remain constant if ICP is to remain constant. The intracranial compartment consists of approximately 83% brain, 11% cerebrospinal fluid (CSF), and 6% blood.

The relationship between ICP and intracranial volume is described by the pressure-volume curve that comprises 3 parts (Fig. 1). The first part of the curve is flat because compensatory reserves are adequate and ICP remains low despite increases in

Disclosures: None.
[a] Department of Neurology, University of Miami-Miller School of Medicine, 1120 Northwest 14th Street, Miami, FL 33136, USA; [b] Intensive Care Department, Son Espases Hospital, Crta Valldemossa 79, Palma de Mallorca, Balearic Islands 07010, Spain
* Corresponding author.
E-mail address: jperezbarcena@med.miami.edu

Crit Care Clin 30 (2014) 735–750
http://dx.doi.org/10.1016/j.ccc.2014.06.005 **criticalcare.theclinics.com**
0749-0704/14/$ – see front matter

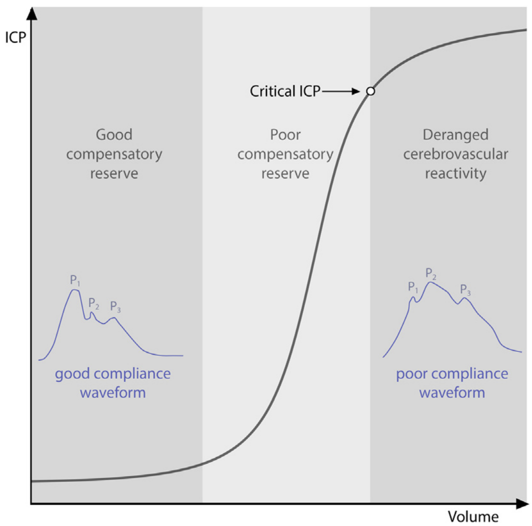

Fig. 1. Relationship between ICP and intracranial volume.

intracerebral volume. When these compensatory mechanisms become exhausted, the pressure-volume curve turns rapidly upwards in an exponential fashion. Intracranial compliance at this point is critically reduced and small increases in intracerebral volume cause a substantial increase in ICP. Thus, ICP is a reflection of the relationship between alterations in craniospinal volume and the ability of the craniospinal axis to accommodate the added volume.

Brain tissue pressure and ICP increase with each cardiac cycle; thus, the ICP waveform is a modified arterial pressure wave. The ICP pressure waveform has 3 distinct components that are related to physiologic parameters. The first peak (P1) is the percussive wave and reflects arterial pressure transmitted from the choroid plexus to the cerebral ventricle. The second peak (P2), often called the tidal wave, is thought due to brain tissue compliance. It is variable and generally increases in amplitude as compliance decreases; if it exceeds the level of the P1 waveform, it indicates a marked decrease in cerebral compliance. The P3 is due to the closure of the aortic valve and therefore illustrates the dicrotic notch (see **Fig. 1**).

METHODS OF ICP MONITORING

ICP cannot be reliably estimated from any specific clinical feature or CT finding and must be measured (**Fig. 2**). Different methods of monitoring ICP have been described but 2 methods are commonly used in clinical practice: intraventricular catheters and intraparenchymal catheter-tip microtransducer systems. The nondominant hemisphere is the preferred site for ICP monitor placement, unless the primary pathology affects the dominant hemisphere, in which case the dominant side is used.[3] Subarachnoid and epidural devices have much lower accuracy and are rarely used.[4,5] Measurement of lumbar CSF pressure does not provide a reliable estimate of ICP and may be dangerous in the presence of increased intracranial hypertension (ICH) because drainage of fluid from the lumbar space may result in a pressure gradient causing downward cerebral herniation.[6]

A ventricular catheter connected to an external strain gauge is the most accurate and low-cost method for ICP monitoring. The catheter is inserted into the lateral ventricle