Cerebral perfusion pressure management through intraventricular intracranial pressure monitoring in spontaneous intracerebral hemorrhage: A case report

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ABSTRACT

Introduction: Management of blood pressure (BP) in patients with spontaneous intracerebral hemorrhage (ICH) concern that significantly elevated BP may precipitate ongoing bleeding, and lowering BP might decrease cerebral perfusion and create secondary ischemia. The target range of BP in patients with ICH should take into account the cause of the hemorrhage, the intracranial pressure (ICP), and whether the patient has a history of hypertension. This case report aims to show the importance of intraventricular ICP monitoring for cerebral perfusion pressure (CPP) management in spontaneous ICH.

Case presentation: A 58-year-old woman presented to the

emergency room with ICH on the left lentiform nucleus. She has conducted an emergency decompressive craniectomy (DC) for trans-Sylvian ICH evacuation with the insertion of an intraventricular ICP monitor. The manual ICP monitor was set up from the external ventricular drainage (EVD) apparatus connected to the infusion line set for measuring ICP. CPP management was done by observing her GCS score, BP, ICP, MAP, and CSF production. On a postoperative day (POD) 4, the ICP monitor was removed due to minimal production of CSF and low ICP measurement in three consecutive days.

Conclusion: Strict ICP and CPP management is paramount in the prevention of secondary injury in spontaneous ICH.

Keywords: cerebral perfusion pressure, hemorrhagic stroke, intracerebral hemorrhage, intracranial pressure

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INTRODUCTION

Blood pressure (BP) management in spontaneous intracerebral hemorrhage (ICH) is essential since increasing BP might involve ongoing bleeding. However, decreasing BP might lead to a decrease of cerebral perfusion, causing secondary ischemia due to the ischemic in the perihematomal region. The cause of hemorrhage, intracranial pressure (ICP) and history of hypertension should be considered in determining target BP of ICH patients.¹⁻³

Maintaining a mean arterial pressure (MAP) in less than 130 mmHg or cerebral perfusion pressure (CPP) in higher than 70 mmHg with ICP monitoring is generally acceptable.¹ Increased ICP is significantly involved in mortality of ICH patients.⁴ Mass effect and local edema exerted by the hematoma or hydrocephalus might have increased ICP. Despite its various criteria for ICP monitoring, the guidelines from American Heart Association (AHA)/American Stroke Association (ASA) recommend ICP monitoring in patients with Glasgow Outcome Scale (GCS) score < 9 associated with mass effect from intracranial hematoma, the clinical manifestation of trans-tentorial herniation,

and significant intraventricular hemorrhage (IVH) or hydrocephalus.⁵ When it is feasible, intraventricular ICP monitor is favored over intraparenchymal since ventriculostomy could be performed as a therapeutic intervention by draining the cerebrospinal fluid (CSF) in increased ICP.^{1,5,6}

Here we reported a case to emphasize the importance of intraventricular ICP monitoring for CPP management in spontaneous ICH.

CASE PRESENTATION

A 58-year-old woman came to the emergency room with a sudden decrease of consciousness for 4 hours before admission. She was also presented with right-sided hemiparesis. She had a history of uncontrolled hypertension for the last seven months and a previous stroke attack seven months ago. On admission, her BP was 150/90 mmHg, and the GCS score was E2V2M5. Brain Computed Tomography (CT) scan was performed. ICH of the left lentiform nucleus was found with volume 40.5 ml (**Figure 1**)

An emergency decompressive craniectomy (DC) for trans-Sylvian ICH evacuation with the insertion of intraventricular ICP monitoring in the

Figure 1. Axial view of brain CT scan showing a hyperdense lesion in the left lentiform nucleus indicating an ICH.

Figure 2. Postoperative CT scan showing ICH has been evacuated with bone decompression and insertion of intraventricular ICP monitoring in the right frontal horn of the lateral ventricle.

right Kocher point was performed to the patient. On the immediate postoperative day (POD), the patient made a good improvement with GCS score E4V2M5. Postoperative CT scan shows the removal of ICH, the tip of intraventricular ICP monitoring in the right lateral ventricle, and adequate bone decompression (**Figure 2**).

Manual ICP monitoring in this patient was set up from the external ventricular drainage (EVD) apparatus connected to the infusion line set for measuring the ICP (**Figure 3**). From this modification device, we can continuously drainage the cerebrospinal fluid (CSF) based on the EVD set up point as well as measuring the ICP. Data regarding the patient's condition were presented in **Table 1**.

DISCUSSION

Brain tissue has a higher metabolic demand compared to tissue in other organs; thus, brain tissue is more susceptible to vascular perfusion changes. Despite the changes in CPP, cerebral blood flow (CBF) and perfusion are maintained at a constant level by autoregulation. ICP remains constant in the physiologic state. Therefore, changes of MAP and by extension systolic blood pressure (SBP) could primarily influence the CPP.⁷ Normal adult CPP is generally between 50 – 150 mmHg but it is usually maintained in 70-90 mmHg.⁸

Cerebral arteries play an important role in maintaining constant CBF by performing constriction as a response to increased CPP and dilatation as a response to decreased CPP. The suspected mechanism is the autonomic response change in the tone of vascular smooth muscle because of vasoactive substances discharged by vascular endothelium (myogenic hypothesis), and changes in transmural pressure identified by periadventitial nerves (neurogenic hypothesis). Normal autoregulation response occurred within 15 – 30 seconds after the identified CPP changes.^{9,10}

CPP is attributed to the gradient of transmural pressure. CPP is the differential pressure between arterial inflow and venous outflow (referred to ICP). CPP can also be used to describe the differential of MAP and pressure surrounding the vessel wall (ICP).^{6,11,12} Cardiovascular function is related to CPP, while a decrease in BP could lead to ischemia. An episode of hypotension is associated with two-fold in the incidence of morbidity and mortality. Besides, a significant increase in BP could cause damage to the blood-brain barrier (BBB) and result in further brain edema.⁸

Several types of monitoring have been widely used to assess ICP. The intraventricular catheter is the most common type of ICP monitor in recent

years. The intraventricular ICP monitor provides two advantages, less distortion compared to other modalities and the ability to evacuate CSF for management of intracranial hypertension. Intraventricular ICP monitor is commonly inserted through Kocher's point in the frontal lobe.¹³

The target of ICP management in spontaneous ICH is generally to maintain ICP between 20 – 25 mmHg with CPP over 70 mmHg.⁶ The ICP management for ICH is predominantly following the recommendation from traumatic brain injury (TBI) ICP management since the protocols had been firmly established.¹

The AHA/ASA guidelines have described the

approach of ICP management for ICH, including the CSF drainage (when feasible), osmotherapy with intermittent mannitol administration, mild hyperventilation, and sedatives and muscle relaxants if necessary. It is generally acceptable and appropriate to attribute the therapy individually and emphasize the efficacy of each modality before additional therapies, mainly due to the serious adverse event resulted from some of these treatments.¹

The appropriate management of BP in ICH had been long deliberated. Some recommendations are suggesting in decrease BP to reduce the risk of bleeding, brain edema, and systemic hypertensive complications. It remains unclear whether the BP elevation is the result or the cause of ICH while its prevalence is usually high. Some conditions might also be responsible for causing persistent increased BP following acute ICH, i.e., pain, stress, increased ICP, and history of hypertension. Increase BP in the acute phase of ICH can lead to several complications, including the expansion of hematoma, recurrent bleeding, worsening of neurological deficits, and death. Management of increased BP in acute hemorrhagic stroke following AHA/ASA 2015 recommendations are described below:⁵

- Class I (level of evidence A) recommendation: decreasing SBP to 140 mmHg is safe and effective to improve functional outcome in ICH patients with SBP between 150 – 220 mmHg without contraindication to acute blood pressure treatment.
- Class II (level of evidence B) recommendation: aggressive reduction of BP with a continuous intravenous infusion and frequent BP monitoring is acceptable for ICH patients with SBP > 220 mmHg.

In our case, the patient underwent manual intraventricular ICP monitor insertion to maintain the target MAP. The ICP showed 10 cmH₂O or 14.7 mmHg in POD 1. We wanted to maintain the CPP between 70 – 90 mmHg. Therefore, our target MAP was calculated as $CPP + MAP = 84.7 - 104.7$ mmHg. This result is the range of BP we maintained

Figure 3. Intraventricular ICP monitor was modified from an EVD apparatus. An infusion line was connected to the apparatus through a three-way connector: one way is to continuously drainage the CSF based on set up point, another way is to measure the ICP.

Table 1. Patient's data from POD 1-3.

POD	GCS Score	BP (mmHg)	Target CPP (mmHg)	ICP (cmH ₂ O, mmHg)	Target MAP (CPP + ICP, mmHg)	Actual MAP (mmHg)	EVD set up point (cmH ₂ O)	CSF drainage (ml, in 24 hours)
1	E4V2M5	146/86	70-90	20, 14.7	84.7-104.7	106	15	70
2	E4V2M5	139/80	70-90	10, 7.3	77.3-97.3	99.7	15	60
3	E4V2M5	130/80	70-90	10, 7.3	77.3-97.3	96.7	20	20

On POD 4, the ICP monitor was removed due to minimal production of CSF and low ICP measurement in three consecutive days.

in regulating BP. The mean of the actual daily MAP was 106 mmHg. We applied the same guidelines in POD 2 and 3 (**Table 1**). The intraventricular ICP monitor was removed in POD 4 as the ICP was successfully maintained within normal range with minimal daily CSF production.

CONCLUSION

Spontaneous ICH is a common disorder with high morbidity and mortality. Hemodynamics must be managed in a way that maintains adequate cerebral perfusion. Strict ICP and CPP management is paramount in the prevention of secondary injury. Fortunately, the brain possesses some innate ability to respond to inadequate cerebral perfusion. To fully appreciate these mechanisms and gain insight into interventions that help us to maintain cerebral perfusion, it is first necessary to understand the mechanics of CBF and autoregulation.

CONFLICT OF INTEREST

There is no potential conflict of interest relevant to this article reported.

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AUTHOR'S CONTRIBUTION

YKA was drafting the article, collecting the data, searching and reviewing the literature, reviewing the manuscript, and revising the article. FB was drafting the article and collecting the data.

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