

# Advanced Pediatric Emergency Medicine Assembly

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## **Ketamine and Head Injury Revisited: Harmful or Helpful?**

Classic teaching in emergency medicine dictates that ketamine should be avoided in the head-injured patient. However, recent studies have shown that ketamine may actually have some neuro-protective effects including increased cerebral blood flow and decreased intracranial pressure. This course will present the evidence to help determine if ketamine is harmful or helpful for children receiving procedural sedation or rapid sequence intubation.

- Determine the role of ketamine in head injury based on current evidence.
- Discuss the effects of ketamine on children requiring procedural sedation and rapid sequence intubation for head injury.

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11:45 AM - 12:15 PM

(+)No significant financial relationships to disclose

### **(+)Joseph A. Carcillo, MD**

Associate Professor, Critical Care Medicine and Pediatrics, member of the Center for Clinical Pharmacology, University of Pittsburgh School of Medicine. Dr. Carcillo has studied the role of fluid resuscitation in the emergency department setting in children in shock. Task Force Chair of the American College of Critical Care Medicine Task Force on Hemodynamic Support of Children and Newborns with Septic Shock. These early goal-directed guidelines have also been adopted by the American Heart Association in their *Pediatric Advanced Life Support* guidelines.

# Ketamine for Brain Injury?

American College of Emergency  
Physicians

Joseph A. Carcillo M.D.

# What is an Ideal Induction drug

- Can be given orally, IM, or IV
- Provides Anesthesia, Amnesia, Analgesia
- Rapid onset
- Maintains cerebral blood flow
- Maintains protective airway reflexes
- Maintains hemodynamic stability
- Reverses bronchospasm
- Anti-inflammatory

# Ketamine is an Ideal Induction drug

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# Why Don't we use Ketamine for Intubating the Head Injured?

The Case Against It is based on  
Three Studies

# **Cerebrospinal fluid during dissociative anesthesia with ketamine**

(Gardner AE et al, Anesthesiology 1971 35:226-228)

- Two patients requiring pneumo ventriculograms given 2 mg /kg/iv ketamine and allowed to breathe spontaneously
- Patient 1 – Obstructed CSF pathway with glioma had rise in CSF pressure from 31.5 mm/Hg to 84 mm Hg. Cerebral Perfusion pressure by 32.6 mm/Hg
- Patient 2 – Normal CSF pathway CSF pressure increased from 3.2 mm Hg to 13.7 mm Hg. Cerebral Perfusion Pressure increased by 3.6 mm Hg
- Both patients had rise in Blood Pressure, Heart Rate, and Respiratory Rate

## **Ketamine anesthesia in patients with intracranial pathology** (Shapiro et al Br J Anesthesia 1972 44:1200-1204)

- Seven patients with CSF shunts, given 2 mg/kg or iv or 4 mg/kg im
- Two patients with normal CSF pathways and no raised ICP initially demonstrated a small rise in ICP which remained below 10 mm Hg. But an increase in Cerebral Perfusion Pressure from 14 to 121 mm Hg in one and a decrease of 5 mm Hg to 83 mm Hg in the other.
- The Five patients with obstructed CSF pathways all exhibited increased ICP and decreased cerebral perfusion pressure
- Other studies have similarly reported this difference between patients with normal and abnormal CSF pathways.

## The effects of ketamine on cerebral circulation and metabolism in man (Takeshita et al Anesthesiol 1972;36:69-75)

- 3 mg/kg ketamine given to healthy volunteers
- Led to increased Cerebral Blood Flow and a reduction in Cerebrovascular Resistance suggesting Cerebral vasodilation
- Cerebral Perfusion increased by 14 mm Hg to 88 mm Hg and metabolism stayed the same
- PaCO<sub>2</sub> increased slightly

# Conclusion of argument against Ketamine use in Brain Injury

- Ketamine raises ICP deleteriously without maintenance of cerebral perfusion only in patients with obstructed CSF pathways
- Ketamine generally improves cerebral perfusion pressure in patients with unobstructed CSF pathways

# The Case for using Ketamine in Brain injured patients without obstructed CSF pathways

Relevant Human Studies

# Ketamine is user friendly

- Frequent choice of anaesthetic in settings where levels of monitoring facility, trained staff are relatively low for example in developing world and field hospitals
- Ease of administration and overall protection against cardiopulmonary compromise make it relatively safe (Ketcham DW Trop Doct 1990 20;163-166, Trouburst A et al Injury 1987 18;96-99)
- Reported complication rates are low (Green SM et al 1996 Acad Emerg Med 1996 3 598-604)
- Procedures using ketamine can be performed either with or without controlled ventilation (Tighe SQM Mil Med 1994 159;86-90)

# Pre-hospital Ketamine for Trauma Patients

- Prospective Clinical Trial reported no early complications from ketamine use to aid pre hospital intubation in trauma patients even when head trauma

(Gofrit ON et al Ketamine in the field: the use of ketamine for induction of anesthesia before intubation of injured patients in the field Injury 1997 28; 41-43)

- Ketamine used in extrication of four patients, one with basal skull fracture. All had full recovery.

(Cottingham and Thomson J Accid Emerg Med 1994 11:189-191)

# Ketamine decreased ICP in Ventilated Patients

- Ketamine produced a reduction in ICP and EEG activity at doses of 1.5, 3, and 5 mg/kg with no change in Cerebral Perfusion Pressure in Propofol sedated ventilated patients with Traumatic Brain Injury

(Albanese J et al. Anesthesiology 1997;87:562-567)

- Ketamine produced a slight reduction in ICP without increasing cerebral blood flow velocity in patients undergoing isoflurane/nitrous oxide anesthesia for craniotomy

(Mayberg et al Anesth Analg 1995;81:84-89)

## Two Randomized Controlled Trials in Traumatic Brain Injury Show Ketamine Sedation Safety

Compared to sufentanyl / midazolam, ketamine / midazolam had no significant effect on mean daily ICP or CPP in patients with severe TBI. But trended to reduced vasopressor requirement

(Bourgoin A et al Crit Care Med 2003;31:711-717)

Compared to fentanyl / midazolam, ketamine / midazolam decreased vasopressor requirements and increased CPP with only a slightly higher ICP in patients with moderate to severe head injury. But had no effect on outcome at 6 months

(Kolenda H et al Acta Neurochir. (Wien) 1996;138:1193-1199)

# Conclusions : Ketamine for Traumatic Brain Injury

- Ketamine is the most widely used anesthetic in the world (Ducharme J Emerg Med 2001:13;7-8)
- Early studies performed showing increased ICP were in patients with non-traumatic intracranial lesions, often with CSF flow obstruction
- They do not apply to TBI because compensatory mechanisms of CSF, venous blood and brain tissue distribution are intact (Langfitt TW Clin Neurosurg 1968;16:436-471)
- Therefore increased CBV can occur without causing a large increase in ICP. A rise in ICP with ketamine is accompanied by a rise in systemic BP, CPP and CBF.
- Vasoresponsivity to CO<sub>2</sub> is retained with ketamine

# Conclusions: Ketamine and Traumatic Brain Injury

- In the setting of multiple trauma with hypotension and traumatic brain injury, ketamine can maintain CPP
- In experimental model of hypovolemia and increased ICP, ketamine increased CPP with a small change in ICP (Klose R et al Anaesthetist 1982:31:33-38)
- Our current practice of avoiding ketamine in rapid sequence intubation for traumatic brain injury is not evidence based.
- A formal RCT of ketamine use as an induction agent in head injury compared to other options (eg thiopentone, propofol, fentanyl, and etomidate) is warranted.