Ketamine and Trauma:
Uses and Limitations

Noah K. Rosenberg, MD
Trauma in Rwanda

2013 Police Data in Kigali:

4689 road traffic crash victims

Patel et al. BMC Public Health (2016) 16:697
Mixed Messages

Ketamine
Goals

• To understand:
  • ketamine as anesthetic and analgesic
  • pharmacokinetics of ketamine
  • pharmacology of NMDA blockade
  • limitations of ketamine
Ketamine
History of Ketamine

- Ketamine was synthesized in 1962 and released for clinical use in 1970
- It is on the WHO list of essential medications.
Ketamine mechanism of action

- Non-competitive NMDA antagonist
- Dissociative anesthetic at high doses
- Analgesic at lower doses
Ketamine mechanism of action

- Anesthetic effect starts around 0.6-2 µg/ml or 1-2 mg/kg
- Analgesic effect begins at about 0.1 µg/ml or 0.1-0.3 mg/kg
- Lipid soluble with large volume of distribution, two compartment model
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Distribution half-life, ~10 min
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Distribution half-life, ~10 min

Elimination half-life, ~2 hrs
Anesthetic concentration
Anesthetic concentration
Anesthetic concentration
Duration of action: 10-15 minutes
Analgesic concentration
Duration of action: >4 hrs
Analgesic concentration
Duration of action: >4 hrs
Sedation
Ketamine in adult procedural sedation

• Ketamine for pediatric procedural sedation is well documented to be safe and effective

• Several recent studies have explored ketamine for adult procedural sedation
Ketamine in adult procedural sedation

Intravenous ketamine for adult procedural sedation in the emergency department: a prospective cohort study

A Newton, L Fitton

Ketamine in adult procedural sedation

- Newton 2008
  - 92 adults received ketamine for procedural sedation. Prospective, observational.
  - Given 0.5-1.0 mg/kg ketamine
  - Adequate sedation and successful procedure in 99% of patients. Recovery agitation occurred in 12 patients (13%)
Pain management
Need for analgesia

- Mandate to minimize suffering.
- Stress--increased inflammatory response. Correlation with thrombotic events, immunosuppression
- PTSD and chronic pain have also been associated with inadequately controlled acute pain.

Malchow RJ, Black IH. Crit Care Med 2008;36;346-7
Factors Affecting Emergency Department Opioid Administration to Severely Injured Patients

Martha L. Neighbor, MD, Samantha Honner, MD, Michael A. Kohn, MD, MPP

Abstract

Objectives: Studies of emergency department (ED) pain management in patients with trauma have been mostly restricted to patients with fractures, yet the potential for undertreatment of more severely injured patients is great. The authors sought to identify factors associated with failure to receive ED opioid administration in patients with acute trauma who subsequently required hospitalization. Methods: At an urban Level 1 trauma center and teaching hospital, a retrospective cohort study of trauma team activation patients requiring hospitalization between January 1 and December 31, 1999, was conducted. The authors excluded patients receiving opioids only within ten minutes of chest tube insertion or fracture manipulation. The main outcome measure was ED opioid administration. Results: A total of 540 charts of hospitalized first-tier trauma team activation patients were reviewed. A total of 258 (47.8%) received intravenous opioid analgesia within three hours of ED arrival. The median time to receiving the first dose of opioids was 95 minutes. Patients were independently less likely to receive opioids if they were younger or older, were intubated, had a lower Revised Trauma Score, or did not require fracture manipulation. Patients with these factors were less likely to receive opioids independent of the amount of time they spent in the ED. Conclusions: Many trauma activation patients requiring hospitalization do not receive opioid analgesia in the ED. Patients at particular risk for oligoanalgesia include those who are younger or older and those who are more seriously injured, as defined by a lower Revised Trauma Score, lower Glasgow Coma Scale score, and intubation. Key words: pain; analgesia; trauma; injury. ACADEMIC EMERGENCY MEDICINE 2004; 11: 1290–1296.
Current state of pain management in trauma
• Neighbor 2004

• Retrospective cohort study. All trauma team activations that resulted in admission over one year

• 540 patients
• Neighbor 2004

• Retrospective cohort study. All trauma team activations that resulted in admission over one year

• 540 patients

• 48% received opioid within 3 hours of arrival.

• More severely injured, lower GCS or intubated less likely to receive opioids
Reasons for oligoanalgesia

• Concern masking pain on exam
• Patient inability to communicate pain or lack of visually striking injury
• Potential for opioids to precipitate hypotension or respiratory depression
• Opioids are inadequate
Reasons for oligoanalgesia

• Potential for opioids to precipitate hypotension or respiratory depression

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Reasons for oligoanalgesia

- Potential for opioids to precipitate hypotension or respiratory depression
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Pathophysiology of Pain
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- Pain is transmitted by A\(\delta\) and C fibers
- Form synapse in dorsal horn. Ascend in anterolateral system
Pathophysiology of Pain

- Pain is transmitted by $A\delta$ and $C$ fibers
- Form synapse in dorsal horn. Ascend in anterolateral system

NMDA receptors
Pathophysiology of Pain

Sensitization and wind-up pain

- NMDA glutamate receptors are involved in central sensitization
- Dorsal horn secondary neurons become hypersensitive to stimulation form primary neurons
Pathophysiology of Pain

Sensitization and wind-up pain

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Sensitization and Wind-up pain

- NMDA receptor is blocked by magnesium under brief pain conditions
- With repeated stimulation magnesium becomes dislodged and even low level painful stimuli causes large depolarization leading to wind-up pain
Pathophysiology of Pain

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Pathophysiology of Pain

- Ketamine provides direct analgesia in the CNS and blocks sensitization and wind-up pain via NMDA blockade
- Pain control independent of opioid system and synergistic with it
- Powerful alternative and adjunct for pain control in the ED
Ketamine and post-op pain

- Extensively studied
- 2009 Cochrane review
- Subanesthetic dosing
- Total of 2137 patients

Ketamine and post-op pain

- Post-op ketamine in subanesthetic doses found to reduce morphine use by 30-50%
- Ketamine related adverse effects were mild or absent.

Ketamine and post-op pain

Limitations
Ketamine was shown to increase ICP in several studies.
Ketamine in head trauma

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Ketamine in head trauma

• No definitive study in ED population but probably safe, with caveat

• Ketamine might be neuroprotective in animal studies but no clinical data exists.

Malchow RJ, Black IH. Crit Care Med 2008;36:346-57
Ketamine and emergence phenomena

- Hallucinatory/delusional responses as patient wakes up.
- Related to misinterpretation of environmental stimuli.
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Ketamine and emergence phenomena

- Uncommon in children
- Incidence in adults varies widely and depends on definition

Ketamine and emergence phenomena

- Effect attenuated or eliminated by benzodiazepines

Ketamine and catecholamine effect

- Catecholamine effect
- Ketamine simulates release of catecholamines and inhibits their reuptake
- Some concern for patients at risk for MI or stroke
- Ketamine has been used successfully in CABG. No reports of adverse events

Ketamine and laryngospasm

• Rare but serious complication

• Uncommon in children and even less so in adults

• Push slowly and have access to RSI

Green, L Acad Emerg Med 2000;7:278-81
Ketamine and myoclonus

- Can interfere with successful completion of intended procedure (joint reduction)
- Incidence is low but consistently reported

Conclusions
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- Ketamine has a short distribution half-life and a long elimination half-life
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- NMDA blockade is synergistic with opioids and may block sensitization to pain.
- Preparation is supported by preclinical data but clinical data is lacking.
Conclusions

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