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# Alternatives to Opioids for Acute Pain Management in the Emergency Department: Part I

*By this time, every physician in the United States should be aware of the opioid crisis in this country. Many emergency patients have chronic pain syndromes and are taking large doses of very potent opioids. While these drugs once were considered to be safe only for patients with terminal cancer, they now are used for chronic pain of almost every cause. The United States uses the vast majority of the world's opiates, perhaps as much as 85%. This widespread use has led to addiction in many patients, black market distribution of drugs, and a very sharp increase in opioid overdoses. Physicians have been prosecuted for distributing large quantities of opioids with little monitoring — so-called pill mills. In response to this crisis, the Centers for Disease Control and Prevention (CDC), among other agencies, has developed guidelines for safe use of opioids. The Surgeon General recently asked physicians to sign a pledge to prescribe opioids safely.*

*Emergency physicians play only a small part in this opioid crisis. While we write a significant number of the prescriptions for opioids, we write only a small percentage of the pills. Most often our prescriptions are for short-term use. Yet, opioid-addicted patients often trace their first exposure to the emergency department (ED).*

*This article and part II, which will follow, discuss alternatives to opioid use in the ED. It is important to note that many of these alternatives are for acute pain. Some patients who are discharged may need further analgesics. It is also important to avoid declaring EDs that adopt some of these practices to be "opiate free." Some patients, such as those with sickle cell vaso-occlusive crisis, advanced cancer, and severe trauma, will require opioids for pain control.*

*— Sandra M. Schneider, MD, Editor*

## Introduction

Historically, people have been experimenting with opium ever since the Sumerians of Mesopotamia cultivated the first poppy plant in 3400 B.C.[1-4] Regardless of the risk of respiratory depression and death, opium quickly became a commodity to be traded, and rapidly spread to every major civilization.[1-3,5]

Today, the use of opiates has become a public health problem affecting families and communities, with a negative impact on health, along with financial impact of lost work productivity, drug rehabilitation, and drug-related crime.[4,6] The World Health Report (2012) estimates 99,000-253,000 illicit drug-related deaths worldwide, with an estimated 70,000-100,000 from opioid overdose each year.[6] In the United States, opioid deaths are on the rise.[1,7] In 2010, there

## EXECUTIVE SUMMARY

- The country is facing an opioid epidemic, with increasing numbers of patients who are addicted to and overdosing on these medications. Alternatives to opioid use in the ED provide the patient with analgesia and, at a minimum, reduced doses of opioid medications.
- Nitrous oxide can be administered safely to patients of all ages undergoing a painful procedure in the ED. It is contraindicated in pregnancy, and must be used with appropriate air scavengers to protect staff.
- Trigger points are identified as taut bands below the skin, which, when pressure is applied, reproduce the pain. Injection of these points reduces pain and may provide rapid relief of pain.
- Injection of trigger points with a dry needle appears to be as effective as injection of local anesthetic into the area.
- Administration of intravenous lidocaine for alleviating acute pain in the ED appears promising in properly selected patients with appropriate monitoring capabilities.

were an estimated 38,329 drug-related deaths in the United States, 16,651 of which were opioid overdoses.[1] By 2014, deaths related to a drug overdose rose to 47,055, of which prescription or illicit opioids accounted for 28,647 deaths.[8]

There appears to be a correlation between the well-meaning efforts of the medical community and legislators and the rise in illicit drug use. Decades ago, physicians were criticized for inadequately managing their patients' pain. A paradigm shift, beginning in the 1980s, challenged physicians to aggressively manage pain. Pain became known as "the fifth vital sign"; the Joint Commission on Accreditation of Healthcare Organizations required pain management for accreditation; the Veterans Health Administration developed pain management initiatives; and various professional organizations developed standards for pain management.[5] These efforts led to aggressive pain management using prescription modalities. However, these efforts inadvertently may have caused an increase in the abuse and addiction to opioids.[9,10]

Emergency physicians have a pivotal role in addressing the growing opioid epidemic. One of the most common chief complaints for an ED visit is pain[12]; and "Acute or chronic pain accounts for almost two-thirds of ED visits in the United States."[2] As key stakeholders, it has become necessary for emergency physicians to identify those patients who may be at risk of abusing opioid prescriptions.[13] Risk factors associated with fatal and nonfatal opioid overdoses include opioid availability; poly-drug use, specifically concomitant use of benzodiazepines; individual tolerance; delay or lack of treatment; male gender; nicotine use; prior substance abuse; and indiscriminate prescribing practices.[1,9,11] Many overdoses are unintentional or occur in the company of others.[11] Administration of naloxone and transport to EDs by first responders provide an opportunity for further emergency intervention, management, and support.[1,9-11]

Over the past 10 years, significant advances have been made to improve our understanding of the neurobiological aspect of pain, with a shift from a symptom-based approach to a mechanistic approach.[14] This approach has led to development of the channels/enzymes/receptors targeted analgesia (CERTA) concept that focuses on patient-specific, pain syndrome-targeted analgesia in the ED. More importantly, this approach allows for broader utilization of combinations of non-opioid analgesics and more refined and judicious use of opioids. These synergistic combinations of different classes of analgesics acting on different target sites will result in greater analgesia and reduced doses of each individual medication that may lead to fewer side effects and shorter length of stay.[15,17]

Multimodal therapies have been used in various medical specialties. They may focus on pharmacologic modalities specifically or may be individualized treatment plans, which include psychosocial support and behavior modification in addition to medications.[18] As an opioid-sparing strategy, multimodal is defined as "using a combination of pharmacologic agents to target multiple receptors known to medicate pain transmission as a means of treating the acute pain episode without including an opioid."[19]

The discussion of multimodal therapy in the ED needs to embrace acute pain management and reflect current practices. Frequently, emergency physicians have used a multimodal approach in treating conditions such as low back pain with the use of analgesics and muscle relaxants.

EDs have begun launching formal alternatives to opioids programs, such as the ALTO℠ program in New Jersey.[6] Such programs are designed to decrease the use of opioids by combining the multimodal pain management approach with a deliberate aim to decrease opioid use. Using therapy designed specifically for several different painful conditions that commonly present to the ED, patients frequently achieve significant pain relief without the use of opioids. Alternative therapies include nitrous oxide, trigger point injections, ultrasound-guided nerve blocks, subdissociative ketamine, and intravenous lidocaine.[17]

Finding alternatives and adjuvants to traditional opioid treatment is beneficial to all patients. However, it is important to remember that some patients, for example those with sickle cell vaso-occlusive crisis or advanced cancer, may need opioids. Efforts to reduce opioids, such as declaring the ED to be "opiate free," may be misinterpreted by these patient groups.

## Nitrous Oxide

### Background/Pharmacology

Nitrous oxide is a colorless nonflammable gas administered in combination with oxygen via inhalation as an analgesic and sedative agent. The maximum percentage of nitrous oxide recommended for administration is 70%, allowing for a minimum of 30% oxygen.

## Table 1. Indications for Use of Nitrous Oxide in the Emergency Department

- Lumbar puncture
- Incision and drainage
- Pre-hospital analgesia
- Extremity fracture
- Central/peripheral venous access
- Joint injections
- Reproducible musculoskeletal pain
- Dental pain
- Joint dislocation
- Headache
- Minor to moderate burns
- Laceration repair
- Venipuncture
- Foreign body removal
- Wound care

Nitrous oxide rapidly reaches the central nervous system within minutes via absorption through the pulmonary vasculature, and does not combine with hemoglobin or other body tissues.[20] There have been no documented cases of nitrous oxide allergy or malignant hyperthermia associated with its use as a single agent.[21] As an analgesic, nitrous oxide is believed to trigger the release of enkephalins that in turn bind to opioid receptors, resulting in an analgesic effect comparable to 10-15 mg of intramuscular morphine.[22,23] Early research revealed nitrous oxide's analgesic effects can be reversed with naloxone.[24,25] Research suggests the anesthetic properties of nitrous oxide are due, in part, to antagonism of the NMDA receptor.[26] Additionally, nitrous oxide may exert its analgesic effects by simply reducing anxiety. Patients with significant anxiety and stress are more refractory to pain relief in the ED; therefore, anxiolysis with medications such as nitrous oxide plays an important role in the management of acute pain.[27,28]

### Indications

**Pediatrics.** Extensive research in the pediatric population has demonstrated nitrous oxide can reduce stress, anxiety, and, thus, pain effectively and safely. The gas maintains an excellent safety record and has been researched in children as young as 1 year of age.[29] Nitrous oxide administration in a 50-70% concentration significantly reduces the pain associated with a variety of painful procedures.

One of the many benefits of using nitrous oxide is the ability for patients to self-administer the gas as needed for analgesia during minor painful procedures.[30] (*See Table 1.*) One study found that venipuncture-associated pain was significantly reduced with at least three minutes of 70% nitrous oxide as compared to 50% nitrous oxide in children 6-15 years of age.[31] A large French survey evaluated the use of an equimolecular mixture of oxygen and nitrous oxide (50:50) in 1,019 children 0-18 years of age undergoing dental care, lumbar puncture, bone marrow aspiration, pulmonary endoscopy, minor surgery, and laceration repair. Seventeen percent of children had additional sedative or analgesic medications administered. The average procedural pain score was 9 on a visual analog scale of 0-100, with side effects reported in 37% of patients, most commonly euphoria (20%), change in visual or auditory perception (7%), and dreams (5.7%). All side effects were transient, lasting less than five minutes with no reported serious adverse events.[32] An equimolecular mixture of nitrous oxide and oxygen was used in lieu of general anesthesia as an analgesic during intra-articular injections in children with juvenile idiopathic arthritis. Seventy injections were performed in 55 children 7-18 years of age, with an average procedural pain score of 2.1 on a scale from 0-10. There were no serious side effects.[33]

Nitrous oxide also can be administered in combination with other sedative agents like intranasal ketamine, midazolam, or fentanyl for procedural sedation.[34-36] Nitrous oxide along with midazolam had marginally better sedation quality with regard to psychomotor side effects when compared to nitrous oxide combined with ketamine.[37] The incidence of serious adverse events is rare and the most common side effects include nausea and vomiting, typically seen with longer administration times and concomitant opioid administration.[38-41] Lastly, high concentration nitrous oxide can be used as a sole agent for minor surgeries, providing excellent analgesia, amnesia, and sedation without fasting requirements or post-surgical monitoring.[42] When used alone, there are no eating or drinking restrictions for nitrous oxide use.[43]

Overall, nitrous oxide is a safe and effective analgesic/sedative in the pediatric population. When used as a sole agent, monitoring should include pulse oximetry; however, when combining agents, full cardiopulmonary monitoring is recommended.

**Adults.** Nitrous oxide provides analgesia and anxiolysis without deep sedation and has been used by a variety of subspecialists for the management of acute pain associated with childbirth, colonoscopy, laser surgery, uterine polypectomy, external version of fetus, and dermatologic and urological procedures.[44-50] There is emerging data regarding its utility as a sole analgesic for acute pain management in the ED when used in a 50-70% concentration. (*See Table 1.*) One study evaluated the effectiveness of nitrous oxide as an analgesic in 85 patients who presented to the ED for pain associated with long bone fracture, joint dislocation, abscess, musculoskeletal pain, abdominal pain, headache, constipation, and burn care. There was a significant reduction in pain scores in patients receiving nitrous oxide. The most common side effects noted were laughter, euphoria, dizziness, and headache. One patient required supplemental oxygen.[51]

Nitrous oxide administration yields an equivalent reduction in pain as compared to intravenous fentanyl 2 mcg/kg for pain associated with extremity long bone fracture. Reported side effects include dizziness, euphoria, and laughter, with rare adverse events such as mild hypoxia, drowsiness, and agitation.[52]

Nitrous oxide is gaining popularity as a prehospital analgesic due to its excellent safety profile, ease of administration, minimal monitoring requirements, and rapid onset of action.[53] Additionally, there is evidence that nitrous oxide in combination with other analgesics can relieve acute exacerbations of cancer

**Table 2. Contraindications to Use of Nitrous Oxide in the Emergency Department**

- Upper respiratory infection/ sinusitis
- Vitamin B12 deficiency
- First and second trimester pregnancy
- Severe asthma/COPD
- Altered mentation (intoxication or psychiatric disease)
- Recent vitreoretinal surgery
- Otitis media
- Pneumothorax
- Bowel obstruction
- Bleomycin treatment
- 5,10-methylenetetrahydrofolate reductase deficiency
- Severe head injury

pain in terminally ill patients.[54] One recent article revealed 50% nitrous oxide is superior in the treatment of pain associated with renal colic when compared to intravenous morphine sulfate.[55] There is limited evidence available regarding nitrous oxide as an analgesic in the adult population. However, the available evidence is compelling and illustrates nitrous oxide use is a well-tolerated, safe, and effective analgesic option in reducing acute pain in the prehospital and adult ED setting.

### Contraindications and Toxicity

Overall, nitrous oxide has proven to be safe and effective, but there are contraindications to its use. (*See Table 2.*) Due to its high solubility, it can diffuse easily into air-filled cavities, and when in enclosed areas can expand, causing trauma. Therefore, in patients who may have a pneumothorax, recent vitreoretinal surgery, otitis media, bowel obstruction, or chronic obstructive pulmonary disease, nitrous oxide is contraindicated.[56-60] There is evidence to suggest exposure may contribute to infertility or spontaneous abortion; therefore, it is contraindicated in the first and second trimesters of pregnancy.[61] Nitrous oxide may interfere with vitamin B12 synthesis and should be avoided in patients with pernicious anemia or other vitamin B12 deficiencies; its use may lead to central nervous system (CNS) toxicity.[62] There have been case reports in the pediatric literature of nitrous oxide-associated myelopathy and polyneuropathy in teenagers who were abusing nitrous oxide recreationally.[63-65] Additionally, one study found that three patients out of 7,802 who were studied developed seizures during or shortly after nitrous oxide administration; two of the three children had seizure disorders.[39] Lastly, there has been one case report of laryngospasm and aspiration reported in a 16-month-old receiving nitrous oxide sedation for laceration repair.[38]

Practitioners who are exposed to nitrous oxide may be at risk for toxicity if a proper scavenging system is not in place; only approved and maintained devices and systems should be used.[66] Additionally, there have been case reports of practitioner abuse of nitrous oxide and even a report of a fatality in a hospital worker.[67] As with any potentially addictive substance, there should be robust security measures to ensure safe handling and storage. Nitrous oxide is considered safe for the majority of patients. With a thorough history and physical exam, clinicians should be able to identify at-risk patients.

### Administration and Dosing

Nitrous oxide works rapidly and should be administered to patients immediately before and throughout a painful procedure. It can be administered via a nasal hood or full face mask. In most ED settings, a mobile portable device is the easiest way to provide the gas; it may require wall oxygen and wall suction access. Depending on the device, nitrous oxide may be delivered via a demand flow or continuous flow delivery system, and will have a maximum of either 50% or 70% nitrous oxide concentration.

Patients should have pulse oximetry monitoring prior to and during nitrous oxide administration. Local anesthetic use and pre-medication with analgesic is still recommended when indicated. The mask or nasal hood should be placed on the patient with oxygen flowing to avoid breathing against dead space in the breathing circuit. Nitrous oxide can be titrated by 10-20% every 30-60 seconds to achieve the desired effect. The patient should be monitored visually for signs of oversedation, such as inability to communicate. Once the procedure is completed, nitrous oxide should be discontinued, and the patient should be allowed to breathe 100% oxygen for one minute. The breathing circuit then can be removed, and the patient should stay seated for one to two minutes breathing room air. At that point, the patient can be discharged without any restriction.

The ability to titrate nitrous oxide rapidly makes it attractive for use in the ED, allowing clinicians to tailor the analgesic needs of each patient with minimal monitoring or post-administration restriction.

## Trigger Point Injection

### Background

Trigger points are painful localized areas of hyperirritable skeletal muscle typically resulting from acute trauma, chronic musculoskeletal disorders, or repetitive microtrauma.[68] They are the hallmark finding of myofascial pain syndrome (MPS), a pain disorder characterized by regional and referred pain in large part due to trigger points within skeletal muscle.[69] Myofascial back pain is second only to arthritis as a leading cause of disability in working-age Americans, and although it is a leading cause of musculoskeletal pain, it is grossly under-recognized as a cause of pain in the ED.[70] Recognition and diagnosis of MPS and its associated trigger points in the ED start with a thorough history and physical exam. The most common presenting complaint in patients with MPS is muscular pain that is exacerbated by movement, and may cause a decreased range of motion in a particular muscle group. The most common muscles involved include the paraspinal cervical muscles of the neck, the upper trapezius muscles, rhomboids, quadratus luborum, and levator scapulae.[71] Pain will be fully reproduced on palpation of the area and will cause referred pain that does not follow a myotomal or dermatomal distribution.[72]

## Table 3. Referred Pain and Mimicking Pathology of Muscles Commonly Affected by Myofascial Pain Syndrome[71]

| Muscle | Muscle Location | Referred Pain | Mimicking Pathology |
|---|---|---|---|
| Trapezius | From occiput to thoracic spine and from the clavicle to the scapular spine | Head, neck, shoulder, and mid-back | Neck, spine, lung conditions (i.e., pneumothorax, meningitis, aortic dissection |
| Iliocostalis thoracis | Axial distribution parallel to thoracic spine; attaches to the lower six ribs | Anterior chest and upper abdomen; correlates with the level of muscle injury | Lung, cardiac, vascular (i.e., pneumothorax, coronary artery syndromes) Upper abdominal visceral condtions (i.e., cholelithiasis and spleen disease) |
| Iliocostalis lumborum | Axial distribution parallel to lumbar spine; from lower six ribs to sacrum and ilium | Lower abdomen and pelvis | Visceral, vascular, and gastrointestinal conditions (i.e., diverticulitis, appendicitis) |
| Quadratus lumborum | Lateral lower back; connects the hip and lower back vertebrae | Lower back, anterior aspect of lower abdomen and pelvis | Lower visceral, gastrointestinal, and gynecological conditions (i.e., appendicitis, ovarian torsion, ectopic pregnancy) |
| Gluteus medius | Inferior-posterior to iliac crest | Lumbar area | Renal and vascular conditions (i.e., urolithiasis, pyelonephritis, abdominal aortic aneurysm) |
| Gluteus minimus | Between posterolateral iliac spine and femoral head | Buttock, lateral thigh, and posterior leg above ankle | Sciatica |
| Paraspinal | Adjacent to the spine | Posterior thoracic and lumbar area | Vascular, thoracic, and retroperitoneal conditions (i.e., aortic dissection) |

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A complicating feature of this syndrome is referred pain, which can mimic other emergency pathologies and delay proper diagnosis.[71] (*See Table 3.*)

Patients often complain of pain with activity that is reproducible but does not follow a dermatomal or nerve root distribution, with preserved nerve function and absence of systemic symptoms.[72,73] Referred pain and location within a taut band are two important and distinguishing characteristics of a trigger point, as compared to a tender point. Tender points, as seen in fibromyalgia, only have pain at the palpated site and most commonly are found within the insertion zone of muscles.[74] Additionally, defining criteria for trigger point identification include a local twitch response that can be appreciated with the application of firm pressure or the insertion of a needle within the trigger point.[73]

Although focal or regional muscle pain is the most common presenting complaint, the spasm associated with a trigger point may produce tension headache, torticollis, jaw pain, and tinnitus.[75-77] A convincing history, palpation of a taut band with tenderness, and referred pain are important indicators of trigger points, as there is no routine laboratory or imaging modality recommendation for confirmation. Ultrasonography and magnetic resonance elastography currently are being investigated as two potential confirmatory imaging studies; however, more research is necessary.[78,79]

Trigger point pain can be managed with analgesics, muscle relaxants, and a variety of nonpharmacologic modalities, such as acupuncture, osteopathic manipulative manual medicine techniques, massage, ultrasonography, and ethyl chloride spray and stretch technique. However, high-quality studies assessing the validity of these modalities are lacking.[71,80] Trigger point injection has been studied and validated as an effective modality for the treatment of pain associated with MPS. Trigger point injection can provide targeted immediate relief by directly inactivating the source of musculoskeletal pain for patients in the ED.[71]

### Indications and Technique

Trigger point injection is indicated in the ED in patients who have a tender, defined, taut band within a muscle belly causing reproducible focal and referred pain. The procedure may include dry needling or wet needling. Dry needling is accomplished by superficially moving a small-gauge solid filament needle in and out of the trigger point by approximately 5-10 mm. This action will mechanically inactivate the trigger point by disrupting the hyperirritable muscle and relieving the pain associated with the muscle dysfunction. Wet needling is a combination of a dry needling technique, with a hollow bore needle, followed with an injection of a variety of medications.[81] Studies have shown that patients have similar pain relief with dry needling alone as compared to wet

**Table 4. Trigger Point Injection Equipment**

- Alcohol or chlorhexadine pads
- Syringe (1-5 mL)
- Local anesthetic
- 22- to 25-gauge needle 1.5-inch
  Superficial (trapezius muscle)
- 21-gauge needle 2.0 inch
  Thick subcuntaneous (gluteus maximus muscle)
- 21-gauge 2.5-inch needle
  Deep (gluteus minimus muscle)
- Adhesive bandage

needling with use of a local anesthetic, botulinum toxin A, steroids, or normal saline.[82-87] The pain relief associated with trigger point injection is thought to be due mainly to the needling effect as compared to the specific injectate used. However, injection of sterile water has been found to be extremely painful and is discouraged.[88] Patients who receive local anesthetic report less discomfort related to post-needling soreness but overall similar myofascial pain relief as compared to dry needling alone.[89] A study of 40 patients treated with 0.25% lidocaine as compared to 1% lidocaine found that the 0.25% concentration was associated with less injection pain.[90] In the ED, performing trigger point injection with local anesthetic is recommended, as it may decrease post-injection soreness and inactivate the pain of trigger point muscle dysfunction.

The most important part of the procedure when performing a trigger point injection is to take the time to accurately identify an active painful trigger point. The injection should be targeted to where the patient has the most local tenderness that fully reproduces their referred pain. Needle selection may vary depending on the thickness of the muscle and its location, as the needle must be long enough to touch and deactivate the targeted muscle.[73] The current recommendation is for providers to use a 22- to 25-gauge 1.5-inch needle for superficial muscle groups such as the trapezius muscle, a 21-gauge 2.0-inch needle for thicker subcutaneous muscles such as the gluteus maximus muscle, or a 21-gauge 2.5-inch needle for deeper muscles such as the gluteus minimus muscle.[71-73] The skin then should be cleansed with alcohol or chlorhexidine and the trigger point should be squeezed between the thumb and index finger to elevate the trigger point. In a sterile fashion, the needle should be inserted at a 30-degree angle to the skin and advanced into the trigger point. Firm pressure should be held on either side of the trigger point. When ready to inject, first aspirate to ensure the needle is not in a blood vessel, then inject a small amount of local anesthetic. The needle then should be withdrawn slightly and redirected in all quadrants of the trigger point laterally, medially, superiorly, and inferiorly while injecting a small amount at each location. Patients may feel a muscle twitch when the needle contacts the trigger point.

When the procedure is completed, an adhesive bandage should be applied. Upon re-evaluation, if the patient continues to have trigger point pain, reinjection is not recommended until there is no longer any localized soreness at the injection site. This may take a few days. The patient should be instructed to stretch the affected muscle groups, despite soreness, and remain active; however, avoiding strenuous activity for 72 hours is recommended.[73]

### Contraindications and Complications

Overall, trigger point injection is safe and with few complications. The only absolute contraindication to the procedure is overlying cellulitis at the site of injection. However, caution should be taken when performing trigger point injection near the apices of the lungs or near intercostal spaces so as to avoid pneumothorax. Additionally, with aggressive needling of the area, there is increased risk of needle breakage and hematoma formation. These can be avoided by never inserting a needle to its hub and by applying firm pressure to the area after injection.[72] There is almost no risk of local anesthetic systemic toxicity, as the volume of local anesthetic used should be very small. However, itt is important to take a good history to ensure the patient has not received any other local anesthetic injections recently and does not have an allergy to the medication.

## Intravenous Lidocaine

### Background

Local anesthetics are one of the most common classes of drugs that are used for topical, local, regional, intra-articular, and systemic (intravenous) anesthesia and analgesia. These local anesthetics (amide and esthers) possess analgesic, anti-hyperalgesic, and anti-inflammatory effects by non-competitively blocking sodium channels. This blockade leads to inhibition of impulse recognition, propagation, and transmission at the injury site, as well as inhibition of ectopic discharges from injured nerve fibers and the dorsal root ganglion.[91,92] The role of intravenous (IV) lidocaine for acute pain management initially stemmed from data in patients with chronic neuropathic pain and postoperative pain.[93] Recently, the analgesic properties of IV lidocaine have been explored in the ED, particularly for patients with renal colic.[91-94]

### Pharmacology

Lidocaine is an amide that non-competitively blocks fast voltage-gated sodium channels of a neuron's cell membrane that prevents depolarization and arrests generation and propagation of painful stimuli.[95] In addition, lidocaine has anti-inflammatory and immunomodulating effects. Lidocaine is absorbed rapidly after IV administration and crosses placental and blood-brain barriers. Lidocaine metabolizes in the liver to active but less potent compounds that are excreted in the kidneys. Renal and hepatic insufficiency leads to accumulation and prolonged half-lives of lidocaine and its metabolites that may lead to neurologic and cardiovascular toxicities.[94,95] Lidocaine produces analgesia and anesthesia with a fast onset of action, relatively short half-life, longer duration of action than procaine, and a better side effect profile than mepivacaine and bupivacaine.[91] For indications, contraindications, dosing regimens, and side

## Table 5. Indications and Contraindications to IV Lidocaine Analgesia

| Indications | Contraindications |
|---|---|
| Acute pain<br>• Renal colic<br>Acute herpetic and post-herpetic neuralgia<br>• Post-operative pain<br>• Low back pain | • Allergy to amides<br>• Pregnancy<br>• Cardiac arrhythmias (AV blocks, extreme tachycardia<br>• Severe coronary artery disease<br>• Severe hepatic and renal insufficiency<br>• Epilepsy |
| Chronic pain<br>• Neuropathic pain<br>• Central pain (post-stroke)<br>• Malignant pain<br>• Chronic headache | |
| Opioid-tolerant pain | |
| Opioid-induced hyperalgesia | |

## Table 6. IV Lidocaine Analgesic Dosing

| Dosing | Comments |
|---|---|
| IV dosing: Single dose<br>• 1-1.5 mg/kg over 10 minutes | • Preservative-free (cardiac) lidocaine only<br>• Short infusion over 10-15 minutes (infuse in 100 mL of NS)<br>• Cardiac monitor for patients > 65 years is strongly advised<br>• Antidote (lipid emulsion) readily available |
| IV dosing: Continuous infusion<br>• 100 mg over 10-15 minutes first<br>• 2-2.5 mg/kg/hr | • Preservative-free (cardiac) lidocaine only<br>• Loading (testing dose) first<br>• Cardiac monitor<br>• Antidote (lipid emulsion) readily available |

## Table 7. Side Effects of IV Lidocaine Analgesia

**Mild**

- Periorbital numbness
- Perioral numbness
- Dizziness
- Dysarthria
- Tinnitus
- Metallic taste

**Severe**

- Seizures
- Anaphylaxis
- Cardiovascular collapse
- Cardiac arrest

effects, see Tables 5-7.

### Clinical Applications

Intravenous lidocaine administered as a single agent, or as an adjunct to opioids, ketamine, and nonsteroidal anti-inflammatory drugs (NSAIDs), has been used widely in a variety of acute and chronic painful conditions (*see Table 5*).[92] Several trials evaluated the analgesic efficacy and safety of IV lidocaine in managing acute painful conditions in the ED related to renal colic, acute low back pain, and post-herpetic neuralgia.

### Renal Colic

Soleimanpour et al published a case series of eight patients presenting to the ED with intractable flank pain due to renal colic who received 1.5 mg/kg 2% lidocaine (preservative-free) over five minutes. Results showed drastic changes in pain score from baseline to 30 minutes (from a score of 9 out of 10 to 2 out of 10) and complete resolution of pain in seven patients. Two patients complained of mild dizziness, and three patients had minimal and transient slurring of speech.[96] Subsequently, Soleimanpour and colleagues randomized 240 ED patients with renal colic to receive 1.5 mg/kg 2% IV lidocaine or 0.1 mg/kg IV morphine given over 10 minutes and demonstrated greater change in pain score at five minutes in the lidocaine group (65% change vs. 53% change) and a significantly greater proportion of patients having change in NRS > 3 in the lidocaine group (90% vs. 70%) at 60 minutes. Both groups had similar rates of side effects (12.5% vs. 13.3%), with dizziness being the most common in the lidocaine group and nausea in the morphine group.[97] The administration of IV lidocaine at 1.5 mg/kg dose as an adjunct to IV morphine given at 0.1 mg/kg demonstrated faster onset of analgesia and greater reduction in nausea and vomiting in comparison to IV morphine alone.[98]

### Acute Back Pain

Tanen et al conducted a randomized, controlled trial comparing 100 mg of IV lidocaine to 30 mg of IV ketorolac for patients with acute lower back pain and demonstrated a greater change in pain score at 60 minutes in the lidocaine group, but significantly higher proportion of patients requiring rescue analgesia in the lidocaine group (65% vs. 50%).[99]

### Post-herpetic Neuralgia

A randomized, placebo-controlled crossover trial that evaluated analgesics and antiallodynic effects of two different doses of IV lidocaine (0.5 mg/kg/hr and 2.5 mg/kg/hr) given for a two-hour period for patients with severe post-herpetic neuralgia demonstrated significant decreases in pressure-provoking pain and allodynia. Of note, no side effects were observed in either group, but the group receiving 2.5 mg/kg/hr dose had a greater reduction in allodynia.[100]

Despite the limited evidence, the role of IV lidocaine given as a single agent or as an adjunct for acute pain management in the ED appears promising. In properly selected patients, this analgesic modality provides effective and safe pain

control. However, before this therapy can be broadly used in the ED, it needs to be studied in larger populations with underlying cardiac disease. In addition, continuous cardiac monitoring is strongly recommended for patients receiving short-term or continuous IV lidocaine infusions in the ED, as well as readily available lipid emulsion (antidote). A department-wide or hospital-wide guidelines and competencies regarding safe administration of IV lidocaine for pain control should be established prior to its initiation.[101]

Part II of this article on acute pain management will discuss ultrasound-guided regional anesthesia and subdissociative dose ketamine.

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## CME/CE Questions

1. What important physical findings can guide clinicians in identifying a trigger point on exam?
   a. Muscular pain isolated to a single muscle group
   b. Presence of a taut band, full reproduction of pain upon palpation, and referred pain
   c. Muscular pain that is not reproducible with movement
   d. Palpation of the tender area produces pain in a specific nerve distribution
2. Which of the following is a disadvantage to using nitrous oxide in the emergency department?
   a. Nitrous oxide delivery in the ED is typically via a mobile unit that must connect to wall oxygen and suction.

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***CME/CE Objectives***

Upon completion of this educational activity, participants should be able to:

- recognize specific conditions in patients presenting to the emergency department;
- apply state-of-the-art diagnostic and therapeutic techniques to patients with the particular medical problems discussed in the publication;
- discuss the differential diagnosis of the particular medical problems discussed in the publication;
- explain both the likely and rare complications that may be associated with the particular medical problems discussed in the publication.

b. Nitrous oxide administration has no NPO requirements.
c. Nitrous oxide is rapidly titratable.
d. Nitrous oxide can be used in all age groups.

3. Which of the following patients should *not* receive nitrous oxide?
   a. A 6-week pregnant woman with a toothache
   b. A 5-year-old child with a laceration
   c. A 15-year-old with a shoulder dislocation
   d. A 70-year-old with a hip fracture
4. Which of the following is *not* a contraindication for nitrous oxide?
   a. Bowel obstruction
   b. Pernicious anemia
   c. Chronic obstructive pulmonary disease
   d. Sickle cell anemia
5. Intravenous lidocaine has been used for analgesia in:
   a. renal colic.
   b. headache.
   c. laceration repair.
   d. shoulder reduction.
6. Trigger points may cause:
   a. torticollis.
   b. tension headache.
   c. jaw pain.
   d. All of the above
7. Combining different approaches to analgesia to address a patient's pain:
   a. reduces the dosage of each drug.
   b. reduces side effects.
   c. produces better analgesia.
   d. All of the above
8. Which of the following is *not* a risk factor for opioids overdose?
   a. Individual tolerance
   b. Female gender
   c. Use of benzodiazepines
   d. History of substance abuse
9. The maximum concentration of nitrous oxide used in the ED is:
   a. 30%.
   b. 50%.
   c. 70%.
   d. 100%.
10. The analgesic effect of nitrous oxide is equivalent to which of the following?
    a. 1-2 mg morphine IM
    b. 5 mg morphine IM
    c. 10-15 mg morphine IM
    d. fentanyl 20 mcg/kg


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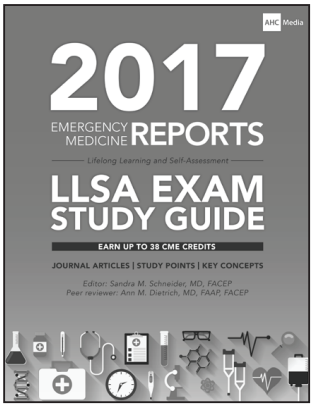


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