

TACTICAL COMBAT CASUALTY CARE: TRANSITIONING BATTLEFIELD LESSONS LEARNED TO OTHER AUSTERE ENVIRONMENTS

Battlefield Analgesia in Tactical Combat Casualty Care



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At the start of the Afghanistan conflict, battlefield analgesia for US military casualties was achieved primarily through the use of intramuscular (IM) morphine. This is a suboptimal choice, since IM morphine is slow-acting, leading to delays in effective pain relief and the risk of overdose and death when dosing is repeated in order to hasten the onset of analgesia. Advances in battlefield analgesia, pioneered initially by Tactical Combat Casualty Care (TCCC), and the Army's 75th Ranger Regiment, have now been incorporated into the Triple-Option Analgesia approach. This novel strategy has gained wide acceptance in the US military. It calls for battlefield analgesia to be achieved using 1 or more of 3 options depending on the casualty's status: 1) the meloxicam and acetaminophen in the combat wound medication pack (CWMP) for casualties with relatively minor pain that are still able to function effectively as combatants if their sensorium is not altered by analgesic medications; 2) oral transmucosal fentanyl citrate (OTFC) for casualties who have moderate to severe pain, but who are not in hemorrhagic shock or respiratory distress, and are not at significant risk for developing either condition; or 3) ketamine for casualties who have moderate to severe pain, but who are in hemorrhagic shock or respiratory distress or are at significant risk for developing either condition. Ketamine may also be used to increase analgesic effect for casualties who have previously been given opioid medication. The present paper outlines the evolution and evidence base for battlefield analgesia as currently recommended by TCCC. It is not intended to be a comprehensive review of all prehospital analgesic options.

Keywords: TCCC, Triple-Option Analgesia, ketamine, fentanyl, OTFC, meloxicam, acetaminophen, pain

Introduction

In the hospital setting, myriad agents are available to provide analgesia, with each having its own indications, advantages, and disadvantages. In the austere combat setting, having many choices can be, at a minimum, confusing and, at its worst, could harm a casualty through the use of an inappropriate pain control agent.¹ In the hospital, a provider has ready access to monitoring equipment, advanced airway equipment, analgesic reversal agents, fluids, and pressor agents to rectify the use of an improper analgesic. In the austere combat setting, few, if any, of these are available. The purpose

of this review is to discuss the current recommendations for battlefield analgesia made by the Committee on Tactical Combat Casualty Care (CoTCCC). We review the evidence for these recommendations as they have evolved from 1996 until the present. The review is not intended to be a comprehensive discussion of prehospital pain control options, but will focus solely on the analgesic options currently recommended by the CoTCCC.

The original Tactical Combat Casualty Care (TCCC) Guidelines recognized the shortcomings of intramuscular (IM) morphine as a battlefield analgesic, and recommended that morphine be administered intravenously (IV) rather than IM both to speed the onset of analgesia and to reduce the likelihood of overdose.²

Oral transmucosal fentanyl citrate (OTFC) and ketamine were subsequently added as additional analgesic options. A 2012 survey of prehospital trauma care in Afghanistan found that combat medics, corpsmen, and Air Force pararescuemen had a positive overall opinion

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of the analgesic options recommended by TCCC, but wanted a more structured approach to determining which analgesic option was most suitable for use in a particular casualty.³ This request resulted in the development of the TCCC Triple-Option Analgesia plan, which is the current standard for battlefield analgesia in the US military.⁴ The Joint Trauma System and the CoTCCC monitor the prehospital literature and update the TCCC recommendations as new evidence becomes available, and additional combat experience is gained. This review presents a brief overview of the evidence for the current TCCC battlefield analgesia recommendations and discusses the applicability of these recommendations to wilderness medicine. A more extensive discussion of the pertinent literature for these recommendations may be found in the 2014 TCCC paper that first presented them.⁴

In 2014, subsequent to the TCCC Guideline updates, wilderness pain control guidelines were developed and released by the Wilderness Medical Society (WMS). These excellent guidelines do not, however, provide the specificity requested and required by the combat medic and subsequently were not adopted by the military.⁵

Discussion

The provision of care in TCCC is divided into phases of care with particular procedures, or medications given in specific care phases.² For the provision of analgesia, the separation of care is minimal. In the Care Under Fire phase, no analgesia is provided. The choices for analgesic agents and the rationale for their use is the same for both the Tactical Field Care (TFC) and the Tactical Evacuation Care (TACEVAC) phases of care in TCCC, thereby simplifying the decision process for combat medical personnel. When utilizing this approach in the wilderness setting, this simplicity would remain. Pain control would not be utilized during a setting of immediate danger (ongoing rock fall or imminent avalanche risk), but would be given once the injured patient is out of immediate danger. All wilderness medicine care, outside of a setting of immediate danger, theoretically falls under the TFC phase of TCCC.

The choice of pain medication recommended for use in TCCC is based on the pain level and hemodynamic stability of a casualty. The degree of pain a casualty is suffering is based on the assessment by the provider. Pain is defined as mild-to-moderate versus moderate-to-severe. The Triple-Option Analgesia approach thus separates analgesia choices for casualties into 1 of 3 categories: 1) casualties with mild to moderate pain; 2) casualties with moderate to severe pain and without actual or impending pulmonary or hemodynamic compromise; or 3) casualties with moderate to

severe pain with actual or impending pulmonary or hemodynamic compromise.⁴

CASUALTY IN MILD-TO-MODERATE PAIN

The goal in a casualty with mild-to-moderate pain is to provide pain relief that does not affect their sensorium. This allows them to either continue to facilitate their mission set or to help facilitate their own medical care and evacuation, depending on circumstances. In the wilderness setting, this would, in particular, apply to the casualties being able to facilitate their own evacuation. In TCCC, a casualty that has mild-to-moderate pain is given a combat wound medication pack (CWMP). This is a prepackaged oral medication combination that is designed to provide the highest level of pain control available that does not affect the mental status of the casualty, impair platelet function, or potentially worsen hypotension or pulmonary compromise. The CWMP was previously called a Combat Pill Pack, but has been redesignated the CWMP in the most recent TCCC update.⁶ A CWMP contains meloxicam, acetaminophen, and moxifloxacin.

COMBAT WOUND MEDICATION PACK MEDICATIONS

Meloxicam 15 mg tablet is a drug of the enolic acid nonsteroidal anti-inflammatory drug (NSAID) class. Its primary advantage over other NSAIDs is its lack of inhibition of platelet function.⁴ Meloxicam is a 90% cyclooxygenase-2 (COX-2) inhibitor, and therefore has minimal effect on platelet function, whereas most NSAIDs have a significant cyclooxygenase-1 (COX-1) effect, which inhibits platelet function. Although some studies on elective surgery patients have shown no effect of acute doses of NSAIDs on bleeding,^{7,8} impaired platelet function can potentiate trauma-induced coagulopathy, which causes increased mortality in combat casualties.^{3,4} Analgesics intended for use on the battlefield should not impair coagulation. The 2 oral pain medications in the TCCC-recommended CWMP (acetaminophen and meloxicam) do not cause either decreased sensorium or decrements in platelet function. The choice of the selective NSAID meloxicam is no more expensive under government pharmaceutical pricing than nonselective NSAIDs.⁹ The first generation of the CWMP contained rofecoxib, a 100% COX-2 NSAID with minimal effect on platelet function. In 2006, after this medication had been found to increase the risk of heart attacks and strokes in patients who were taking it for long periods of time, rofecoxib was removed from the TCCC Guidelines. It was replaced with meloxicam, another selective COX-2 inhibitor.¹⁰ Celecoxib was also considered as a replacement for rofecoxib, but was not

selected because it is contraindicated in individuals with sulfa allergies.

Acetaminophen (paracetamol) 1300 mg (650 mg extended release bilayer tablet x 2) is one of the most familiar pain medications used worldwide. It provides moderate pain relief that is non-sedating. Acetaminophen provides pain relief through a different mechanism than NSAIDs and, given in combination with an NSAID, has an additive effect on pain relief compared to either given alone.^{11,12} Older Combat Pill Packs may contain lower doses or formulations of acetaminophen, but the standard is the 650 mg bilayer tablet x 2 for a total dose of 1300 mg that can be given every 8 hours.

Moxifloxacin is added to the pill pack to allow for an oral antibiotic to be taken as quickly as possible after a combat wound, as all are considered “dirty wounds.”¹³ The addition of an antibiotic may not have as much relevance to civilian wilderness wounds, which do not typically involve penetrating trauma and thus could be left out of a wilderness pill pack.

CASUALTY WITH MODERATE-TO-SEVERE PAIN WITHOUT HEMODYNAMIC OR PULMONARY INSTABILITY

A casualty in moderate-to-severe pain will need pain control beyond what meloxicam, acetaminophen, or combination can provide. Medications effective for treating severe pain will often have some potential negative affect on a casualty's mental status, as well as the potential to negatively affect their hemodynamic or respiratory status. When choosing a medication for severe pain control, the provider must determine if the casualty already has compromised hemodynamic or respiratory status or is at risk of the same. If the casualty has neither of these concerns, then the TCCC recommended medication is OTFC. The present recommendation is to give fentanyl OTFC 800 µg, which comes in a lozenge form.

FENTANYL OTFC—ORAL TRANSMUCOSAL FENTANYL CITRATE

Fentanyl OTFC is a narcotic that has the advantage of both a rapid onset of action without requiring an IV, as well as a

moderately prolonged duration of action. Fentanyl OTFC also causes little histamine release and maintains hemodynamic stability better than most narcotics.¹⁴ The use of fentanyl OTFC in TCCC for the treatment of acute pain is an off-label indication. Fentanyl OTFC is presently approved only for use in treatment of breakthrough pain in individuals who are opioid tolerant. The TCCC recommends its use based on its well-documented safety and efficacy when used for the treatment of acute pain, both in the military and civilian settings.^{15–20}

MECHANISM OF ACTION/ PHARMACODYNAMICS

When the lozenge is placed in the mouth and allowed to dissolve without any chewing, approximately 25% of the drug will be absorbed transmucosally. This provides for a very rapid absorption through the mucosa into the bloodstream, and pain control onset in 5 to 10 minutes. The remaining 75% of the fentanyl is swallowed, entering the GI tract and portal circulation where approximately 67% of this swallowed portion is removed via first pass effect. The remainder of the drug (approximately 25% of the original dose) gives long-lasting pain control for 2 to 6 hours.²¹ TCCC recommended administration guidelines for Fentanyl OTFC are found in [Table 1](#).

CASUALTY IN MODERATE-TO-SEVERE PAIN WITH HEMODYNAMIC OR RESPIRATORY COMPROMISE OR JUDGED TO BE AT RISK OF EITHER CONDITION

In a casualty that has hemodynamic or pulmonary instability, or impending instability, the use of any narcotic, even fentanyl, could potentially worsen their condition. An analgesic without a negative effect on the respiratory or cardiovascular status is the agent of choice. The ideal agent in such a casualty is ketamine, which can be given through a variety of routes: IV, IM, or intranasal (IN). Ketamine has been recommended for pain control use in mountain rescue since 1999 by the International Committee on Alpine Rescue (ICAR).²²

Table 1. How to administer fentanyl OTFC

Place the 800 µg OTFC lozenge between the cheek and gum.
DO NOT CHEW the lozenge - efficacy is reduced if it is chewed.
Tape the stick of the lozenge to a finger or rubber band it to the casualty's body armor to cause removal from the mouth in case of somnolence.
If severe pain persists after 15 min, add a second OTFC lozenge to the opposite cheek.
Consider ondansetron 4 mg oral dissolving tablet, IM, or IV as needed for nausea/emesis.
Monitor for respiratory depression.
Remove weapons (eg, firearms, knives, etc.) from any casualty given OTFC.

Ketamine

Ketamine is a dissociative medication with amnestic, sedative, and analgesic properties. It has an excellent safety profile. At low doses, it is primarily an analgesic with minimal effects on the sensorium. As the dose increases, however, it causes significant dissociation and amnesia. It is an agent with a very high therapeutic index. In standard dosing, ketamine maintains a casualty's airway reflexes and maintains hemodynamic stability. In fact, "the quantity of ketamine has no clinically important effect on airway integrity and respirations within the range of clinically administered doses."²³ Ketamine also potentiates the analgesic effect of opioids when the two medications are used in combination. This dual analgesic approach for severe pain allows effective pain control to be achieved with lower doses of opioids, which in turn reduces the likelihood of opioid-induced adverse effects on blood pressure or respirations.²⁴ There are a few considerations to recognize when utilizing ketamine.

KETAMINE CONTRAINDICATIONS

Absolute contraindications to ketamine use are few, but include a history of schizophrenia and very young age.²⁵ Ketamine use in pain control doses can stimulate psychosis in those with existing schizophrenia. Ketamine use is also not recommended in children less than 3 months of age due to a higher risk of airway problems.²⁶

KETAMINE USE IN HEAD INJURY

Previously, ketamine was thought to be contraindicated for use in casualties with moderate to severe traumatic brain injury (TBI), due to concerns that ketamine might cause elevations in intracranial pressure (ICP). Recent literature shows this concern to be clinically unfounded, particularly in a patient conscious enough to complain of pain. The most recent literature shows ketamine to have no effect on ICP, or lower ICP. Ketamine is therefore considered safe to use in head injury/TBI in a patient who complains of pain.^{27–34} The exception to this is in a patient with a preexisting hydrocephalous due to an anatomic obstruction. In this situation, ketamine should not be used as it could raise ICP.³⁵ It was in this unique situation that the original literature found dissociative dose ketamine could definitively raise ICP.

The one area of continued debate with ketamine use and head injury is in the hemodynamically stable trauma patient with severe TBI. In this patient cohort, when dissociative dose ketamine is given, it remains unclear if a casualty also needs to be intubated and sedated to

avoid any adverse effects from ketamine use. It is clear that in severe traumatic head injury, if the patient is ventilated and sedated, there is Oxford level 2b, grade C evidence that ketamine dose not increase ICP.^{36,37} In the case of the hemodynamically unstable patient, all other analgesics carry significant risk with their use. With ketamine, "the drug has major advantages in those patients with associated hemodynamic compromise, and should potentially be regarded as the agent of choice."^{38,39} Thus, ketamine is the TCCC prehospital choice for pain control in the hemodynamically unstable patient.

KETAMINE SIDE EFFECTS

Ketamine side effects are rare, but include laryngospasm, apneic episodes, emesis, and neuropsychiatric "emergence" phenomena. Laryngospasm can occur in up to 0.3% of cases. This incidence is based on a large pediatric review done by Bellolio.⁴⁰ An initial apneic episode can occur when IV ketamine is given by very rapid IV push (in less than 30 seconds). This occurs in (0.8%) of cases given by rapid IV push.⁴¹ Emesis is one of the most common side effects to occur in those given ketamine. It is seen most commonly on awakening (5–15%), and the risk is highest with IM dosing.⁴² Neuropsychiatric "emergence" phenomena occur in 5 to 30% of patients receiving dissociative dose ketamine.⁴³ Neuropsychiatric symptoms also occur with subdissociative dosing to a lesser, but dose-dependent extent.⁴⁴

KETAMINE EFFECT ON OCULAR PRESSURE

Ketamine has been reported to increase intraocular pressure (IOP) and this caused it to be considered relatively contraindicated for use in individuals with known or suspected globe injuries in the past. However, more recent studies have found that the ketamine-induced changes in IOP are not clinically significant.^{45,46} In the TCCC Guidelines, known or suspected open globe injuries do not preclude the use of ketamine.⁴ The minimal potential for slight medication-induced elevations in IOP—with the resulting possibility of worsening visual outcomes for casualties with open globe injuries—is outweighed by the need to provide effective battlefield analgesia that does not further compromise a hemodynamically unstable casualty, or one at risk of respiratory compromise from pulmonary injuries. The use of opioids to relieve pain is clearly contraindicated in such casualties and ketamine is a better choice.⁴

In addition, blast-related fragment injuries may cause a vision-threatening retrobulbar hematoma. The use of ketamine in higher doses may be useful in providing

analgesia for an emergency lateral canthotomy should one need to be performed in the prehospital combat setting and the use of local anesthesia be infeasible in that setting.

KETAMINE DOSING: LOW DOSE/ANALGESIC DOSE/SUBDISSOCIATIVE DOSE

In low doses, ketamine provides analgesia with an intact sensorium.⁴⁷ This is the subdissociative pain control dosing used in TCCC, and the dose recommended for wilderness use. The terms low dose, analgesic, pain control dose, and subdissociative dose are frequently used interchangeably to refer to this dosing of ketamine. This subdissociative analgesic dose is 0.3 to 0.5 mg/kg IV, IM, IN, or intraosseous (IO). The TCCC recommended dosing of ketamine is found in [Table 2](#).

KETAMINE DOSING: HIGH DOSE/DISSOCIATIVE DOSE/SEDATION DOSE

At doses above 0.5 mg/kg IV ketamine has a dissociative threshold at which it fully dissociates the patient from his or her sensorium. A dissociation sedative is defined by the American College of Emergency Physicians (ACEP) as, “A trance-like cataplectic state characterized by profound analgesia and amnesia, with retention of protective airway reflexes, spontaneous respirations, and cardiopulmonary stability.”⁴⁸ Dissociation begins with ketamine doses above 0.5 mg/kg IV and continues until the dissociative threshold is reached. The dissociative threshold is 1 to 2 mg/kg IV; commonly seen at 1 mg/kg IV in adults and 1.5 to 2 mg/kg IV in children, or 3 to 4 mg/kg IM in both. At these dose ranges, the patient is completely dissociated. Doses above this do not increase the depth of dissociation, although they do prolong the dissociative duration. TCCC Guidelines do not recommend ketamine use in dissociative doses.

Table 2. Tactical Combat Casualty Care Guideline recommendations for ketamine

Give initial 20 mg if IV or IO.
Repeat q20 min as required.
Give initial 50 mg if IM.
Repeat q30 min as required.
Can also give IN if nasal atomizer available.
Give initial 50 mg if IN.
Repeat q30 min as required.
Give IV over 30 to 60 seconds to avoid rare apnea.
Onset is in 1 min if IV, 5 min if IM or IN.
Remove weapons from any casualty given ketamine.

PAIN CONTROL MEDICATIONS BEYOND THE TRIPLE-OPTION ANALGESIA APPROACH: INTRAVENOUS MORPHINE

If the pain from combat injuries is severe and there is no contraindication to using opioids, OTFC is recommended because it provides safe, effective analgesia without requiring that the individual providing care establish IV access to administer analgesic medications.

When vascular access has already been established, however, morphine (5 mg IV or IO every 10 minutes with careful monitoring for respiratory depression) is another good option.^{4,6} IM morphine is not recommended in TCCC due to its highly variable absorption, its unpredictable clinical efficacy, and the increased potential for opioid overdose when multiple doses are administered while awaiting the delayed onset of analgesia typical of IM morphine.⁴⁹

TRAINING, LEGAL, AND COST CONSIDERATIONS FOR WILDERNESS USE

The TCCC Triple-Option Analgesia plan is designed for combat medical personnel, including combat medics, corpsmen, and pararescuemen. Some of these individuals are trained only to the emergency medical technician-basic (EMT-B) level (but with additional training specific to the combat setting). This approach to battlefield analgesia is, however, also perfectly well suited for use by more advanced providers. The TCCC Triple-Option Analgesia approach is simple in concept, provides rapid and effective analgesia, and maximizes safety by avoiding opioid use in casualties with hemodynamic and/or respiratory compromise.

The TCCC Triple-Option Analgesia approach lends itself very well to the wilderness environment.⁵⁰ A practice guideline mirroring the TCCC Triple-Option Analgesia approach was published by the ACEP.⁵¹ The current WMS practice guidelines for analgesia also include a discussion of the analgesic options called for in TCCC.⁵ The ACEP and WMS guidelines provide information on additional wilderness analgesics for those interested in options that go beyond the TCCC focus of this paper. The ICAR Guidelines for pain control also recommend the use of both narcotics and ketamine.²² A wilderness version of the CWMP that could be used by anyone might consist of 2 nonprescription medications, such as acetaminophen and ibuprofen.

Local, regional, and international laws and protocols will determine what medications can be carried and utilized. The medications recommended in the TCCC Triple-Option Analgesia strategy are now generally well accepted by the medical oversight authorities in the US military, but US civilian EMS protocols and legal

restrictions in other countries may limit the ability of prehospital medical personnel to use this approach. The transport and use of controlled substances for wilderness settings and expedition medicine must be in accordance with specific legal requirements of the locations involved.⁵²

Cost may also be a significant factor in what medications are carried and utilized. Generic nonprescription medications such as acetaminophen and ibuprofen are available at minimal cost, whereas fentanyl OTFC can cost several hundred dollars per lozenge. The individual provider will need to decide which analgesics he or she should carry based on cost as well as regulatory considerations.

Conclusions

The TCCC Triple-Option Analgesia approach to relief of pain on the battlefield provides a simple, effective, and safe plan that can be used by the frontline military medic to treat a casualty's pain. This plan has been successfully utilized by the US military since 2014. OTFC and ketamine were used individually for years prior to that.⁴ OTFC was documented to be safely used in more than 300 US casualties prior to 2010.^{16,19} The CWMP—under different names and with some changes in specific contents—has also been successfully utilized by military units since 2003.⁵³ The Triple-Option Analgesia plan has to date, however, not been used in the civilian wilderness setting, despite this extensive positive experience with this approach in military forces. Traumatic injuries that occur in the wilderness setting could be considered the same as an event occurring in the TFC phase of TCCC. For these traumatic injuries, TCCC pain control guidelines can be both safe and effective. The use of these same guidelines in the wilderness setting can provide an option for the appropriate and safe pain relief of injured wilderness sojourners.

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