Paracostal Infusion of Bupivacaine for Management of Rib Fracture Pain

SUMMARY

Patients who sustain multiple rib fractures (≥ 3 rib fractures) have difficulty with pain control, maintaining adequate ventilation and oxygenation. The mainstay of pain management in these patients has centered on opioid analgesics, which, in addition to providing analgesia, may also lead to respiratory depression. The goal of therapy for these patients is to achieve adequate pain control and prevent the development of pneumonia or the need for long-term mechanical ventilation.

RECOMMENDATIONS

- **Level 1**
  - **None**
- **Level 2**
  - **None**
- **Level 3**
  - **Consider paracostal bupivacaine infusions in any patient with ≥ 3 rib fractures.**
  - **Consider paracostal bupivacaine infusions in patients with rib fractures and pre-existing pulmonary disease, increased work of breathing/splinting, and/or inadequate pain control.**
  - **Use a standardized order set for continuous paracostal bupivacaine infusions.**
  - **Use only bupivacaine 0.25% solution.**
  - **Set a MAXIMUM TOTAL daily dose of 480 mg/day – regardless of catheter number.**
  - **All patients should be started at an initial MAXIMUM TOTAL rate of 8 mL / hr.**
    - **Double lumen: recommended initial starting dose is 4 mL / hr/ lumen**
    - **Each lumen should have a clearly labeled infusion rate.**
  - **24 hours after initiation, re-evaluate the patient's pain status:**
    - **Unconscious patient – re-evaluate ventilator status**
    - **Conscious patient – assess incentive spirometer volumes and pain scores**
    - **If adequate pain control, consider decreasing the rate by half**
  - **Allow the medication to run out and reassess patient's pain management prior to refilling the elastomeric infusion pump.**
  - **Use should not exceed a maximum of two 600 mL elastomeric pumps per patient.**
  - **Consider adjunctive pain management with oral or intravenous opioids and/or oral or intravenous non-steroidal anti-inflammatory agents (NSAIDs).**
  - **Ensure aggressive pulmonary toilet.**

INTRODUCTION

Numerous modalities have been tried to achieve adequate pain control in patients with multiple rib fractures. These modalities include oral or IV opioid analgesics, nerve blocks, and epidural infusions. The use of the On-Q C-bloc Select-a-Flow infusion pump to deliver subcutaneous local anesthetic

EVIDENCE DEFINITIONS

- **Class I:** Prospective randomized controlled trial.
- **Class II:** Prospective clinical study or retrospective analysis of reliable data. Includes observational, cohort, prevalence, or case control studies.
- **Class III:** Retrospective study. Includes database or registry reviews, large series of case reports, expert opinion.
- **Technology assessment:** A technology study which does not lend itself to classification in the above-mentioned format. Devices are evaluated in terms of their accuracy, reliability, therapeutic potential, or cost effectiveness.

LEVEL OF RECOMMENDATION DEFINITIONS

- **Level 1:** Convincingly justifiable based on available scientific information alone. Usually based on Class I data or strong Class II evidence if randomized testing is inappropriate. Conversely, low quality or contradictory Class I data may be insufficient to support a Level I recommendation.
- **Level 2:** Reasonably justifiable based on available scientific evidence and strongly supported by expert opinion. Usually supported by Class II data or a preponderance of Class III evidence.
- **Level 3:** Supported by available data, but scientific evidence is lacking. Generally supported by Class III data. Useful for educational purposes and in guiding future clinical research.

(bupivacaine or ropivacaine) in patients with rib fractures is a newer modality. The literature available to support this modality is limited primarily to case series and abstracts.

INDICATIONS

- The use of continuous paracostal infusion of bupivacaine may be considered in any patient with multiple (≥ 3) rib fractures (3,4,6,7).
- The use of continuous paracostal infusion of bupivacaine may also be considered in patients with rib fractures and additional co-morbidities including:
  - Pre-existing pulmonary disease
  - Increased work of breathing and/or splinting
  - Inadequate pain control
- Elderly patients (age > 55 years), especially those with preexisting pulmonary disease, may benefit from the use of a continuous paracostal bupivacaine infusion even if they have < 3 rib fractures.

LITERATURE REVIEW

Bupivacaine Pharmacology

Bupivacaine is an amide-type long-acting local anesthetic. It has an onset of action of 5-10 minutes with a duration of action of up to 7 hours (1). The plasma half-life of bupivacaine is approximately 2-2.5 hours (2). Bupivacaine causes local or regional anesthesia through stabilization of neural membranes and prevention of nerve impulse transmission (1). In additional to local anesthesia, bupivacaine also causes stimulation of the central nervous system (CNS), decreased electrical excitability in the myocardium, and may inhibit platelet aggregation (1). These effects lead to the primary adverse events described with bupivacaine. Bupivacaine is intended to provide local or regional anesthesia via epidural, subcutaneous/intradermal (local), intrapleural, retrobulbar, or peripheral nerve blocks. It is not intended to be administered intravenously.

Adverse Events

Bupivacaine is not without adverse events when given in large doses and/or administered intravenously. Bupivacaine does stimulate the CNS and at high serum concentrations (> 4 mcg/mL in adult patients) may result in restlessness, tremor, nystagmus, and clonic convulsions (1,2). Bupivacaine is also a myocardial depressant and when given in high doses or by intravenous injection may lead to bradycardia, hypotension, heart block, ventricular arrhythmias (including ventricular fibrillation) and cardiac arrest (1,2). Prolonged (2-3 weeks) epidural infusion of bupivacaine has also been associated with elevation of liver function tests which resolved upon discontinuation of the infusion (1). Finally, there is some *in vitro* data that suggests bupivacaine may inhibit platelet aggregation (1). Intravenous lipid infusions may be used as part of the treatment of the severe adverse events (cardiovascular & neuro) – the usual starting dose is 1.5 mL/kg bolus of 20% lipid emulsion, then 0.25 mL/kg/min for 30-60min. The bolus may be repeated and the infusion rate increased to 0.5 mL/kg/min if there is no clinical improvement (1).

Use of continuous paracostal infusion of bupivacaine via an elastomeric pump for rib fractures

Epidural anesthesia or intercostal nerve blocks have been well described for the treatment of pain associated with rib fractures. In contrast, the use of subcutaneously-placed catheters to deliver bupivacaine locally to treat pain in patients with rib fractures is a relatively new procedure. Truitt et al. described the procedure and have provided an educational video to assist with learning the technique (http://filesanywhere.com/fs/v.aspx?v=896f638e5f636faf6b6e).

Truitt et al. provided the results of their clinical experience with the subcutaneously-placed catheters and infusion of ropivacaine controlled by an elastomeric pump. They evaluated the results in ten adult patients who had >3 unilateral rib fractures after blunt trauma. They demonstrated a decrease in pain scores and an increase in lung volumes (pre-placement incentive spirometer (IS) volume = 0.5 L, post-placement IS = 1.1 L) after placement of the catheters and initiation of the infusion. None of the patients required mechanical ventilation or developed pneumonia. The catheters remained in place 68-84 hours (3).

Halm et al. also provided results of their clinical experience with the continuous catheter-directed intercostal nerve block (CCICNB) with ropivacaine in patients with multiple rib fractures (range 4-24). They retrospectively reviewed 124 patients treated with CCICNB. The patients received an average dose of ropivacaine of 472 $\pm$ 186 mg/day for an average of 13.6 $\pm$ 6.8 days. The authors demonstrated statistically significant decreases in pain scores (assessed using visual-analogue scales), morphine equivalent requirements and sedation, and a significant increase in incentive spirometry volumes. Twenty-nine of the 31 patients who were intubated prior to placement of the CCICNB were extubated (4).

Maximal infusion rate when administered via elastomeric pump
Currently, no published data exists; thus, the ultimate decision lies with the surgeon who inserts the device. Based on the package insert and manufacturer recommendations, the intravenous maximum recommended daily dose is 400 mg/24 hours (when administered without epinephrine as is the case when using elastomeric pumps) (1). The elastomeric pumps allow up to 14 mL/hr. When using bupivacaine 0.25% (2.5mg/mL) solution, a total rate of 14 mL/hr provides 840 mg/24 hours. There is no literature currently available to provide information on the amount of systemic absorption of bupivacaine when administered subcutaneously to patients with rib fractures. Based on safety concerns, a consensus was reached by the Surgical Critical Care Attending Surgeons at Orlando Regional Medical Center to set a maximum total rate (the sum of all lumens) at 8 mL/hr of 0.25% bupivacaine which provides 480 mg/24 hours.

Adjunctive Analgesia Options
There is a paucity of literature directly analyzing the efficacy and safety of systemic opioids and/or non-steroidal anti-inflammatory agents (NSAIDs) for the treatment of pain associated with rib fractures. However, it has been well described that patients with rib fractures and poor pain control have increased respiratory complications (5).

A review of the literature conducted by Karmakar et al., discusses the various modalities available including systemic opioids, intercostal nerve block, epidural analgesia, intrathecal opioids, and transcutaneous electrical nerve stimulation. In reviewing the literature, patients who received epidural anesthesia or regional nerve blocks appeared to achieve better pain control and improved pulmonary function as compared to the opioid-only groups. All of the studies were small and of short duration (5).

Mackersie et al. evaluated the use of continuous-infusion epidural or intravenous fentanyl for pain management in patients with rib fractures. Both groups saw improvement in pain scores (on visual analogue scale measurements) and improvement in ventilator function following administration of fentanyl. However, there was no statistically significant difference between the two groups (6).

Ingalls et al. conducted a randomized, double-blind, placebo-controlled trial using lidocaine patch 5% in patients with traumatic rib fractures. The results demonstrated that the patch did not provide improvement in pain control in these patients (7).

There is currently no literature on the use of NSAIDs for the treatment of pain associated with rib fractures. NSAIDs do provide adequate analgesia in many other settings and their use may frequently lower overall opioid requirements in post-operative patients. This was demonstrated by Southworth et al in a randomized, double-blind, placebo-controlled trial on the use of intravenous ibuprofen (400 mg or 800 mg per dose) for post-operative pain management. They enrolled 406 patients (87 men, 319 women) who had undergone either elective abdominal (73%) or orthopedic (27%) surgery. Patients received ibuprofen injection 400 or 800 mg or placebo administered every 6 hours in addition to intravenous morphine. There was a significant reduction in the median total morphine dose at 24 hours in patients receiving ibuprofen 800 mg IV q 6hr as compared to placebo ($p=0.026$). There was no difference between the ibuprofen 400 mg group and placebo. The ibuprofen 800 mg group also had significant reductions in pain at rest and with movement as compared to placebo ($p < 0.05$) (8).

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