Intercostal Nerve Block with Liposomal Bupivacaine vs Epidural Analgesia for the Treatment of Traumatic Rib Fracture

Nicholas W Sheets, MD, MPH, James W Davis, MD, FACS, Rachel C Dirks, PhD, Alan W Pang, MD, Amy M Kwok, MD, MPH, FACS, Mary M Wolfe, MD, FACS, Lawrence P Sue, MD, FACS

BACKGROUND: Rib fractures are common among trauma patients and analgesia remains the cornerstone of treatment. Intercostal nerve blocks provide analgesia but are limited by the duration of the anesthetic. This study compares outcomes of epidural analgesia with intercostal nerve block using liposomal bupivacaine for the treatment of traumatic rib fractures.

METHODS: A retrospective chart review was used to identify patients who received either epidural analgesia or intercostal nerve block with liposomal bupivacaine for the treatment of traumatic rib fractures. Patients were matched in a 1:1 ratio on age, Injury Severity Score, and number of rib fractures. Outcomes included intubations, mechanical ventilation days, ICU length of stay (LOS), hospital LOS, and mortality.

RESULTS: After matching, 116 patients were included in the study. Patients receiving intercostal nerve blocks with liposomal bupivacaine were less likely to require intubation (3% vs 17%; $p = 0.015$), had shorter hospital LOS (mean ± SD 8 ± 6 days vs 11 ± 9 days; $p = 0.020$) and ICU LOS (mean ± SD 2 ± 5 days vs 5 ± 6 days; $p = 0.007$). There were no differences in ventilator days or mortality. Minor complications occurred in 26% of patients that received an epidural catheter for rib fractures. No complications occurred in the patients receiving intercostal nerve block.

CONCLUSIONS: Patients who received intercostal nerve blocks with liposomal bupivacaine required intubation less frequently and had shorter ICU and hospital LOS compared with epidural analgesia patients. These results suggest that intercostal nerve blocks with liposomal bupivacaine might be equal or superior to epidural analgesia. (J Am Coll Surg 2020;231:150−154. © 2020 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

Rib fractures occur in approximately 9% of trauma patients and are associated with increased mortality.[1] Maintaining pulmonary mechanics and hygiene through adequate analgesia has shown a mortality benefit and therefore remains the cornerstone for rib fracture management.[1,2] Multiple modalities have been used to improve patient outcomes after experiencing traumatic rib fractures. Oral and IV medications have been mainstays of management, and current studies have reported the benefits of epidural, paravertebral, and serratus plane analgesia for the treatment of rib fractures.[3-6] Research has explored intercostal nerve blocks for analgesia, but studies have questioned the potential benefit of this modality.

Previous studies using bupivacaine have shown improvement in pain, peak expiratory flow, and arterial oxygen saturation after intercostal nerve block, but the initial benefits diminish after the first 24 hours from injection.[7,8] Although the use of thoracic epidurals for the treatment of traumatic rib fractures has been examined, few comparative studies of the 2 modalities have been performed.[3,9-11] Intercostal nerve blocks can have the benefit of fewer complications and fewer contraindications, but a limiting factor of this modality is

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From the Department of Surgery, University of California San Francisco, Fresno, CA.

Correspondence address: James W Davis, MD, FACS, Department of Surgery, University of California San Francisco, 2823 Fresno St, 1st Floor, Fresno, CA 93721. email: jdavis@fresno.ucsf.edu

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the longevity of the anesthetic used for the procedure; therefore, newer methods are needed.[10]

Liposomal bupivacaine is a 72-hour slow-release anesthetic used frequently for orthopaedic and plastic surgery procedures and is associated with a reduced hospital length of stay (LOS).[12-15] Studies have shown the beneficial effects of liposomal bupivacaine for intercostal blocks during video-assisted thoracoscopic procedures, yet no study has evaluated this medication for intercostal nerve blocks in the treatment of traumatic rib fractures.[12] This study seeks to compare outcomes of epidural analgesia with intercostal nerve block using liposomal bupivacaine for the treatment of traumatic rib fractures. We anticipate that intercostal nerve blocks with liposomal bupivacaine will lead to fewer patients requiring mechanical ventilation, fewer days of mechanical ventilation, and decreased ICU and hospital LOS.

METHODS

A retrospective chart review was performed at Community Regional Medical Center, an American College of Surgeons-verified Level I trauma center in Fresno, CA. Patients with rib fractures from December 2014 to March 2019 were identified through the trauma registry. Patient inclusion criteria included 18 years or older, blunt mechanism of trauma, presence of 3 or more rib fractures, and use of epidural analgesia or intercostal nerve block using liposomal bupivacaine. Patients with a Glasgow Coma Scale score <14 on arrival and those intubated before arrival or during their initial resuscitation were excluded. Demographic information was collected including sex, age, mechanism of injury, Injury Severity Score, body region Abbreviated Injury Scale score, number of rib fractures, chest tube placement, presence of hemothorax or pneumothorax, pulmonary contusions, smoker status, and history of COPD. Primary outcomes variables included intubations, mechanical ventilation days, ICU LOS, hospital LOS, and mortality. Secondary outcomes variables included ventilation-associated pneumonia, pulmonary embolism, and epidural catheter and intercostal nerve block complications.

The decision to perform an intercostal nerve block with liposomal bupivacaine or epidural catheter placement was made by the senior resident or attending. Intercostal nerve block procedures are performed by surgical residents, surgical physician assistants, or emergency medicine residents. After informed consent, the number and location of the rib fractures was determined from the CT scan and the area was prepped and draped. Each intercostal site was located using either ultrasound-guided technique or landmark technique, depending on physician experience and patient body habitus. Liposomal bupivacaine was dispensed in a 20-mL vial (266 mg/20 mL). Intercostal injections were at least 5 mL per intercostal space and for more than 4 sites, the liposomal bupivacaine was diluted with an appropriate amount of IV saline. Injections were done with a 22-gauge needle. A post-procedure chest x-ray was obtained after the intercostal block.

Epidural catheter placement was performed by an anesthesiologist or certified registered nurse anesthetist. Epidural infusion medication was left to the discretion of the anesthesiologist. The infusion was titrated daily for patient comfort. The institutional practice is generally to leave the catheter in place for 5 days, absent any sign of complication or unless the anesthesiologist and/or attending trauma surgeon decide to remove the catheter at a different time.

Statistical analysis was performed by comparing patients receiving intercostal nerve block with liposomal bupivacaine with patients with epidural analgesia. Patients were matched in a 1:1 ratio on age, Injury Severity Score, and number of rib fractures. Continuous data are presented as mean ± SD and categorical data as percentages. Data were analyzed using chi-square analysis and Wilcoxon signed rank tests. Statistics were performed using the SPSS Software, version 23.0 (IBM Corp). This study was approved by the IRB of Community Medical Centers/University of California San Francisco, Fresno.

Table 1. Patient Demographic Characteristics by Treatment Group

Characteristic	Rib block (n = 58)	Epidural (n = 58)	p Value
Age, y, mean ± SD	60 ± 19	60 ± 19	0.32
Sex, m, n (%)	39 (67)	39 (67)	1.00
Current smoker, n (%)	6 (10)	7 (12)	0.77
COPD, n (%)	6 (10)	6 (10)	1.00
Rib fracture, n, median (IQR)	8 (6–9)	8 (6–9)	0.53
Head AIS, median (IQR)	0 (0–2)	0 (0–1)	0.74
Chest AIS, median (IQR)	3 (3–3)	3 (3–3)	0.46
Abdomen AIS, median (IQR)	0 (0–2)	0 (0–2)	0.61
Injury Severity Score, median (IQR)	14 (10–17)	14 (12–18)	0.93
Chest tube, n (%)	18 (31)	21 (36)	0.56
Hemothorax, n (%)	10 (17)	9 (16)	0.80
Pneumothorax, n (%)	18 (31)	21 (36)	0.56
Pulmonary contusion, n (%)	18 (31)	21 (36)	0.56
Flail chest, n (%)	9 (16)	11 (19)	0.62

AIS, Abbreviated Injury Scale; IQR, interquartile range.

RESULTS

During the study period, 11,694 trauma patients 18 years and older were admitted to Community Regional Medical Center and 2,433 patients had rib fractures. Of these patients, 358 had a Glasgow Coma Scale score <14 and were excluded. Of the remaining 1,431 patients, 230 received intercostal nerve block with liposomal bupivacaine and 62 had epidural analgesia. There were 10 patients intubated during the initial resuscitation for respiratory failure (distress, hypoxia, or tachypnea) and were excluded (4 epidural analgesia and 6 intercostal nerve block with liposomal bupivacaine). After matching, 116 patients were included in the study with 58 patients in each group. Demographics including age, number of rib fractures, and Injury Severity Score were similar between groups (Table 1). There were no significant differences in time from patient presentation to procedure between the 2 groups (mean ± SD 1 ± 1 day vs 1 ± 1 day; p = 0.91).

Primary outcomes demonstrated statistically significant differences for patients requiring intubation, ICU LOS, and hospital LOS (Table 2). Patients receiving intercostal nerve blocks using liposomal bupivacaine were less likely to require intubation (3% vs 17%; p = 0.015), had shorter hospital LOS (mean ± SD 8 ± 6 days vs 11 ± 9 days; p = 0.020) and ICU LOS (2 ± 5 days vs 5 ± 6 days; p = 0.007). There was no difference in the median number of rib fractures (6 vs 7; p = 0.5). There were no cases of ventilator-associated pneumonia. The incidence of pulmonary embolism was not different between groups (2% vs 3%; p = 0.56).

Minor complications occurred in 15 of 58 patients (26%) that received an epidural catheter for rib fractures. Complications included dislodgement, broken catheter, catheter deemed nonfunctional, or patient became hypotensive with medication administration, requiring treatment for the hypotension. Mean ± SD catheter presence was 4 ± 1 days. There were no complications in the intercostal nerve block group (p < 0.001).

DISCUSSION

Analgesia remains the primary treatment for traumatic rib fractures, as it helps restore pulmonary mechanics and improve outcomes, yet studies comparing different modalities show mixed results about which is the most

Table 2. Patient Outcomes by Treatment Group

Outcomes	Rib block (n = 58)	Epidural (n = 58)	p Value
Intubation, n (%)	2 (3)	10 (17)	0.015
Ventilator, d, mean ± SD	1 ± 4	2 ± 5	0.083
ICU LOS, d, mean ± SD	2 ± 5	5 ± 6	0.007
Hospital LOS, d, mean ± SD	8 ± 6	11 ± 9	0.020
Mortality, n (%)	2 (3)	1 (2)	0.56

LOS, length of stay.

efficacious.[3,7,9,10,16] Recent guidelines from the Eastern Association for the Surgery of Trauma and the Trauma Anesthesiology Society concerning the treatment of blunt thoracic trauma conditionally recommend epidural analgesia and a multimodal approach, but high-quality studies are lacking.[17] Although epidural analgesia has been widely studied, few comparative studies have been performed comparing this modality with intercostal nerve blocks. These studies have shown mixed results in ICU and hospital LOS.[3,9-11] One concern about the use of intercostal nerve block is the limited duration of pain relief.[7,8] Studies evaluating continuous intercostal nerve block with the on-Q pump suggest a reduction in ICU and hospital LOS that are not seen in shorter-acting anesthetic studies.[9-11] Recognizing this opportunity for improvement, we present the first study comparing intercostal nerve block with liposomal bupivacaine with the current recommended treatment of epidural analgesia.

The current study found that patients who received intercostal nerve blocks with liposomal bupivacaine required intubation less frequently and had shorter ICU and hospital LOS compared with epidural analgesia patients. These results might suggest that intercostal nerve blocks with liposomal bupivacaine can be equal or superior to epidural analgesia. Although intercostal nerve block can have marginal benefits to epidural anesthesia, there are several clinical advantages of this modality. Some contraindications to epidural anesthesia include coagulopathy and spinal fractures, which are common among trauma patients. These contraindications are less prevalent for the patients receiving intercostal nerve block, making this treatment more widely available for trauma patients. At our institution, intercostal nerve blocks can be performed by a surgeon, emergency medicine physician, or anesthesiologist, compared with epidurals catheters, which are placed by anesthesiologists only. Previous authors have commented on the faster placement of the intercostal nerve block.[10] Although our study did not show a significant difference in time to procedure in the matter of days, fewer contraindications and widely available providers to perform the procedure might have differences in the matter of hours that can affect outcomes.

Epidural catheters have been shown to have common minor complications and very rare major complications.[18,19] In the recent article by Peek and colleagues,[19] 47% of patients who received an epidural catheter for rib fracture analgesia encountered a minor complication. Most complications (76%) were due to medication side effects, and the remaining patients (24%) experienced catheter-related complications. In this study, 26% of patients experienced a minor epidural complication and there were no major complications, which appears consistent with previous literature.[18,19] Patients with a catheter-related complication usually had the catheter removed due to malfunction or concern for sterility of the appliance. Few studies have evaluated the complications of intercostal nerve block placement. The reported rate has ranged from 8.7%[21] to 0%.[7,8,10] The most commonly reported complication is pneumothorax, but Shanti and colleagues[20] recognized the risk of delayed presentation of pneumothorax after blunt chest trauma and how this might affect their results. They suggest that the true incidence of complications from intercostal nerve block might be overestimated. Our current study did not identify any complications for intercostal nerve blocks. With an extremely low risk of complications from intercostal nerve block, the benefits appear to far outweigh the risks.

Limitations of this study include the retrospective design, which limited the collection of patient pain perception and pulmonary mechanics. Pain scores and incentive spirometry volumes were not uniformly recorded in the medical record. Although time to procedure was measured in days, the precise time to procedure was unable to be calculated accurately, which might have prevented finding significant differences between the 2 groups. Without randomization, we were unable to control which treatments were offered to patients, as well as determine why specific treatments were offered. Additionally, this study is underpowered to examine differences for ventilator-associated pneumonia or pulmonary embolism, as mobility and anticoagulation practices are altered at the time of epidural catheter placement compared with intercostal nerve blocks. With a larger study, more clinically relevant differences can be seen.

CONCLUSIONS

This study found that patients receiving intercostal nerve blocks with liposomal bupivacaine for traumatic rib fracture required fewer intubations and had a shorter ICU and hospital LOS when matched and compared with patients treated with epidural analgesia. Considering the current study, we recommend consideration of intercostal nerve blocks with liposomal bupivacaine in all patients with traumatic rib fractures.

Author Contributions

Study conception and design: Sheets, Davis, Dirks, Pang, Kwok, Wolfe, Sue

Acquisition of data: Sheets, Davis, Dirks, Pang

Analysis and interpretation of data: Sheets, Davis, Dirks, Pang, Sue

Drafting of manuscript: Sheets, Davis, Dirks, Pang
Critical revision: Sheets, Dirks, Kwok, Wolfe, Sue

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