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Out with the Old, In with the New: A Novel Approach to Treating Pain Associated with Rib Fractures

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Abstract
Background Rib fractures continue to be a challenging problem from both a pulmonary and analgesia standpoint. As a result, numerous modalities have been used to treat this condition, but none has proven universally available and efficacious. The objective of this pilot study was to assess the efficacy of a novel technique for placing an elastomeric infusion pump (EIP) catheter (On-Q; Lake Forest, CA, USA) in the extrathoracic paraspinous space to create a continuous intercostal nerve block.
Methods This was a prospective, nonrandomized study conducted in the surgical intensive care unit (SICU) of an urban level II trauma center. We developed a novel technique for placing EIP catheters in the extrathoracic paraspinous space to provide continuous intercostal nerve blockade. We subsequently evaluated 30 consecutive blunt trauma patients with three or more unilateral rib fractures. The catheters were infused with local anesthetic, and the dose was titrated to achieve adequate analgesia. For each patient, preplacement numeric pain scale scores (NPSs) and sustained maximum inspiration (SMI) lung volumes were determined. Sixty minutes following placement of the catheters, the NPS and SMI were repeated. The patients were monitored for any procedural or drug-related complications.
Results The mean age of the patients was 65 years (22–92 years); the mean ISS was 14 (9–16); and the mean number of rib fractures was 4.4 (3–8). Overall, the mean NPS significantly improved (preplacement NPS 9.03, postplacement NPS 3.06; $p < 0.05$) and was associated with a significant increase in the SMI (preplacement SMI 0.40 L, postplacement SMI 1.1 L; $p < 0.05$). The catheters remained in place for an average of 98 h (72–146 h), and there were no procedural- or drug-related complications.
Conclusions These pilot data indicate that the placement of EIP catheters in the extrathoracic paraspinous space may be a safe, viable, and efficacious procedure for ameliorating pain secondary to rib fractures.

Introduction

Rib fractures are the most common injury sustained following blunt trauma [1]. Ziegler and Agarwal noted that in a population of more than 7000 trauma patients, 10% had fractured ribs [2]. These injuries are normally the hallmark of significant chest trauma; and as the number of fractured ribs increases, there is an exponential increase in morbidity and mortality [2, 3].

This injury therefore poses a challenging problem from both pulmonary and analgesia standpoints. Significant morbidity is often the result of hypoventilation leading to atelectasis, pneumonia, and respiratory failure [4]. Pain management has been recognized as an important factor in preventing these complications [4]. As a result, numerous modalities (i.e., epidurals, intercostal nerve block) have been implemented to treat this condition, but none has proven universally available and efficacious.

The objective of this pilot study was to assess a technique, developed by the authors and not previously

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described, for placing an elastomeric infusion pump (EIP) (On-Q; Lake Forest, CA, USA) catheter in the extrathoracic, paraspinous space to create a continuous intercostal nerve block. The EIP has a multiport catheter designed to infuse medication over a broad area that is connected to a single-use elastomeric reservoir that delivers medication at a defined rate. This system has been commonly used for several years in other applications, such as continuous peripheral nerve block and rectus sheath block.

Methods

This prospective, nonrandomized study was conducted in the surgical intensive care unit (SICU) of an urban level II trauma center over a 12-month period. We evaluated 30 consecutive blunt trauma patients with three or more unilateral rib fractures.

Inclusion criteria are the following.

- Three or more unilateral rib fractures in an anatomic pattern feasible for nerve blockade
- Age $\geq$18 years
- Ability to comprehend and endorse an informed consent

Exclusion criteria included the following.

- Field or emergency room intubation prior to placement of an EIP
- Any significant concomitant injuries potentially confounding data acquisition (e.g., traumatic brain injury, long bone fractures, intraabdominal injuries)
- Known allergic reactions or dependence on narcotics or local anesthetics
- Use of additional modalities of pain control prior to enrollment (e.g., other analgesia medications, epidural, paravertebral block)
- Inability to obtain informed consent

We had previously developed and implemented a novel technique to place the EIP catheters in the extrathoracic, paraspinous space to provide continuous intercostal nerve blockade. After successful placement by a single operator (M.S.T.), the two catheters were infused with a local anesthetic (0.2% ropivacaine), and the pump was set at 12 cc/hr to achieve adequate analgesia (Fig. 1).

For each patient, we recorded relevant demographic data, the Injury Severity Score (ISS), number of rib fractures, preplacement numeric pain scale scores (NPSs), and sustained maximal inspiration (SMI) lung volumes. Sixty minutes after placing the catheters, the NPS and SMI were repeated. During the infusion period, each catheter was closely monitored for any procedural- or drug-related complications.

Results

Our urban level II trauma center had 1396 trauma admissions over the 12-month study period. In all, 182 (13%) of

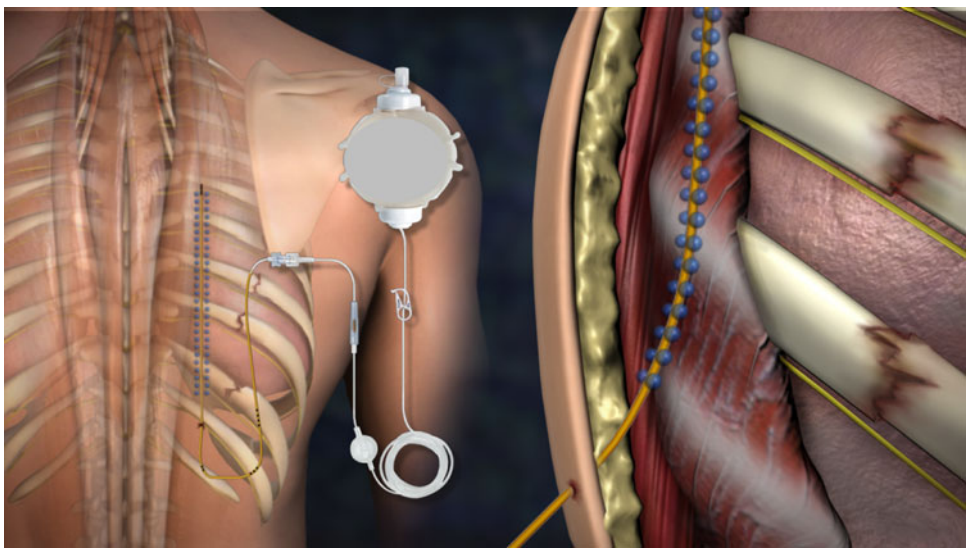

Fig. 1 Anatomy and placement of the catheter. Position the patient in a relaxed lateral decubitus position and identify the insertion site just lateral to the paraspinous muscle. Incise the skin and soft tissue down to the level of the rib. Then, insert the tunneler at a 90° angle until it makes definitive contact with the rib. Advance cephalad at a 45° angle in the extrathoracic space just superficial to the rib. Remove the tunneler and advance the catheter into the pull away sheath. If desired, a second catheter can be placed just lateral to the first. Flush and secure the catheter to the patient. Finally, attach the catheter to a reservoir of 0.2% ropivacaine and set the pump to infuse a total of 12 ml/h

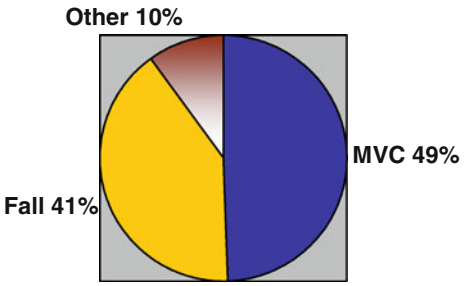

Fig. 2 Rib fracture mechanisms of injury

these patients sustained rib fractures; and 169 of the 182 (93%) patients were admitted to the SICU. The remainder were admitted to the surgical ward. The most common mechanism of injury in the study population was a motor vehicle collision (i.e., motor vehicle, motorcycle, or automobile versus pedestrian), accounting for 49%, followed by falls (41%) and a variety of other mechanisms (10%) (Fig. 2).

The following data are from 30 consecutive blunt trauma patients who met our inclusion criteria. The mean age of the group was 65 years (22–92 years), with a mean ISS of 14 (9–16) and a mean of 4.4 (3–8) rib fractures per patient. Overall results, after placement of the two extrathoracic catheters, revealed a statistically significant improvement in the NPS (preplacement NPS 9.03, postplacement NPS 3.06; $p < 0.05$) (Fig. 3). Additionally, there was a statistically significant increase in the SMI (preplacement SMI 0.40 L, postplacement SMI 1.1 L, $p < 0.05$) (Fig. 3). Only one patient in the study population ultimately required mechanical ventilation. The catheters remained in place for an average of 98 h (72–146 h), and 60% of the patients were discharged home with the therapy in place. There were no procedural- or drug-related complications.

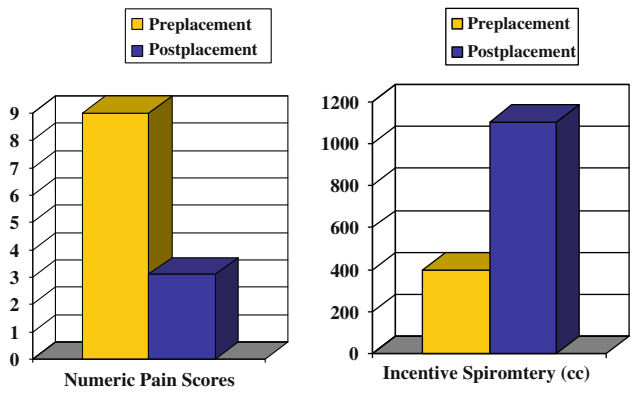

Fig. 3 Numeric pain score (NPS) and sustained maximum inspiration

Discussion

Rib fractures are the most common injury sustained following blunt chest trauma, accounting for more than half of all thoracic injuries [5]. Despite many years and numerous treatment modalities, patients with this injury continue to experience significant morbidity and mortality. The associated pain often requires prolonged hospitalization for the administration of intravenous narcotics or epidural placement. In addition, suboptimal analgesia can lead to poor pulmonary toilet and delayed mobilization. This frequently evolves into the need for ventilator support with its attendant risks and complications [6].

Several strategies have been employed to combat the problems stated above, but none has proven fully efficacious, logistically feasible, and universally available. Historically, percutaneous rib blocks were performed with local anesthetic at the bedside every 8 h. Although this technique provided excellent analgesia, its intermittent nature was prohibitively labor intensive given that each level had to be repeatedly injected [7]. Furthermore, the procedure requires significant experience to ensure efficacy and to minimize complications. As a result, the technique is seldom utilized outside of select teaching environments.

Epidurals have also been employed with varied success, but enthusiasm for placing them in this population is lacking. When placed correctly and expeditiously, pain control is quite good; however, patients frequently have contraindications to placement, and successful placement is impossible in approximately 30% of patients. In addition, epidurals often have the untoward side effect of hypotension, which can make resuscitation of the trauma patient more difficult. Motor blockade, impaired mobility, and difficulties with pharmacologic deep venous thrombosis (DVT) prophylaxis are other confounding variables that limit the use of epidurals in the trauma patient. Finally, the data show no significant improvement in SICU/hospital length of stay (LOS) or mortality when compared to other therapies [8].

Given the difficulties enumerated above with percutaneous rib blockade and epidural placement, physicians frequently defer to patient-controlled analgesia (PCA). Unfortunately, PCA is a systemic treatment for a localized problem and is largely ineffective. Yet, its convenience has led to its widespread adoption. Moreover, the use of PCA-administered opioids for postoperative pain management may be a risk factor for hospital-acquired infections. Morphine has been reported to suppress natural killer (NK) cell activity, and several mechanisms have been proposed for immune suppression caused by opioids [9, 10]. Despite this, PCA is the most frequently used modality for the treatment of pain associated with rib fractures [11].

In 2003, Karmakar and Ho performed a meta-analysis reviewing acute pain management of patients with multiple

rib fractures. Their study compared analgesia using systemic opioids and/or nonsteroidal antiinflammatory drugs versus regional analgesic techniques. Comparison of the two methods revealed regional blocks to be more effective and associated with fewer side effects than systemic therapy. They concluded that based on the current evidence it is difficult to recommend a single method for safe, effective analgesia [6]. Another recently published study showed thoracic paravertebral blocks to be as effective as thoracic epidural analgesia for pain management in patients with rib fractures [11, 12]. Given that no single therapy has proven satisfactory, we endeavored to combine the efficacy of an intermittent intercostal nerve block with the logistical advantages of a continuous epidural while mitigating the risks and adverse effects.

Our study utilized a surgeon-developed and surgeon-implemented novel technique for the placement of two EIP catheters in the extrathoracic, paraspinous space to create a continuous intercostal nerve block. We employed two catheters in this study to maximize the potential benefit to the patient because, to our knowledge, no one had utilized or described this technique previously, and there was no reference to its reproducibility. Our experience since this time has proven the learning curve to be quite short (five to seven placements), and there does not appear to be a clinical benefit to the placement of a second catheter. Our pilot data indicate that this is a potentially efficacious procedure from analgesia and pulmonary standpoints (Fig. 3). In addition, this technique has the potential to benefit the overall care of the patient for the following reasons.

- Consistent placement because there is no risk of epidural hematoma or hypotension
- Logistically feasible as it provides continuous intercostal nerve block
- Earlier mobilization because there is no risk of motor blockade
- Decreased need for systemic analgesics
- Improved compliance with pulmonary toilet, incentive spirometry, and potential avoidance of mechanical ventilation
- Earlier discharge as the patient can be sent home with the therapy in place

Limitations of our study are a lack of randomization and a small study population of only 30 patients. Although we did not experience any placement- or device-related complications, the small number of patients in this study may underestimate the risk of rare complications such as pneumothorax, catheter site infection, or adverse drug reaction. Additional investigation on a larger scale, such as a multicenter, prospective, randomized trial would allow further evaluation of these potential benefits and better define the risk profile of the therapy. This study could also assess the effect on narcotic use, SICU/hospital stay, need for mechanical ventilation, hospital-acquired pneumonia, mortality, and overall cost.

Conclusion

In our pilot study, the placement of EIP catheters in the extrathoracic, paraspinous space appears to be a safe, viable, efficacious procedure for the amelioration of pain secondary to rib fractures.

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