Session: L023
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Analgesic Options for a 68-Year-Old Man With Multiple Rib Fractures

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Stem Case and Key Questions Content

The trauma critical care service consults you to discuss analgesic options with a 68-year-old man who suffered right sided 5th-10th rib fractures from a motor vehicle collision (MVC) 2 days prior. Trauma secondary survey and imaging found no injuries outside the thorax. Mild hemopneumothorax was noted on initial chest x-ray, and a 36 French chest tube was placed. Past medical history is significant for coronary artery disease, type 2 diabetes mellitus, hypertension, and chronic obstructive pulmonary disease. Home medications include aspirin, atenolol, lisinopril, metformin, tiotropium, and PRN albuterol.

What other injuries are commonly associated with multiple traumatic rib fractures?
Why is effective pain control so important in patients with blunt thoracic trauma?
What is the underlying pathophysiology of respiratory decompensation in these patients?

Computed tomography of the chest confirmed likely pulmonary contusion under the rib fractures but no flail segments. The patient has been hemodynamically stable throughout his hospitalization with heart rate in the 70's and systolic blood pressure in the 120's to 140's but complains of severe right sided chest pain particularly with coughing or attempting to take deep breaths.

What analgesic options can anesthesiologists offer to patients with multiple rib fractures?
Are interventional techniques such as thoracic epidural analgesia and paravertebral blockade more effective than analgesic medications?
Is there any evidence than one technique is more efficacious than the other?

The trauma team placed the patient on scheduled acetaminophen and ketorolac as well as a hydromorphine PCA, but he still appears very uncomfortable, taking rapid shallow breaths and rating his pain at 7-8/10. You discuss the options of placing a thoracic epidural catheter or paravertebral catheters.

What are possible side effects and more serious complications of each technique?
Is thoracic paravertebral blockade (TPVB) safer than thoracic epidural analgesia (TEA)?

The patient's respiratory status has continued to decline. Initially ventilating normally and oxygenating adequately on 4L O2 via nasal cannula, he is now mildly somnolent and was placed on BiPAP. Arterial blood gas analysis shows pH 7.28, PaCO2 51 (up from baseline 42) and PaO2 68 (on FiO2 0.5).

What are the anticoagulation contraindications to neuraxial or paravertebral blockade?
Are they different for the two techniques? Should they be?

When reviewing his past medical history, you note that the patient had an LAD drug-eluting stent placed 10 months ago and ask him if he takes any "blood thinners." He admits that he was prescribed "some medicine" that his cardiologist wanted him to continue for the first 12 months after his stent but takes it only sporadically because it costs too much; though unsure of the exact timing of his last dose, hebelieves it was within the last 7 days.

Are coagulation tests helpful to determine safety of block placement when the last medication dose is unknown?
What if the last dose was more recent than allowed in consensus guidelines?
Is it ever appropriate to violate consensus guidelines when performing TEA or TPVB?

Platelet mapping thromboelastography is performed, revealing normal platelet function. After informed consent, decision is made to proceed with thoracic paravertebral catheter placement.

What are the various techniques for thoracic paravertebral blockade?
How does this differ for catheter placement?
How many catheters should be placed in this patient?
Does ultrasound use reduce the risk of complications?

Model Discussion Content

Discussion

Pathophysiology of respiratory
dysfunction in blunt thoracic trauma

Blunt thoracic trauma is consistently linked to high morbidity and mortality, making accurate diagnosis and appropriate treatment essential to optimize outcomes. Rib fractures are common, occurring in up to 26% of traumatic thoracic injuries, and the number of rib fractures independently predicts adverse pulmonary events including death.[1] If present, flail segments or other chest wall deformities alter respiratory mechanics, limiting ventilation, and associated pulmonary contusions can result in worsened ventilation perfusion matching. Uncontrolled pain leads to poor respiratory effort and weak cough, leading to alveolar collapse and ultimately gross atelectasis with increased intrapulmonary shunt. Once pneumothorax is ruled out, noninvasive positive pressure ventilation can be instituted, reducing atelectasis and improving oxygenation and ventilation. However, without adequate analgesia, many patients eventually require intubation and mechanical ventilation, potentially leading to further complications such as ventilator-associated pneumonia.

Analgesic options

Multimodal conservative analgesia using opiates, acetaminophen, and possibly nonsteroidal anti-inflammatory agents is ideal if tolerated from a respiratory standpoint but often fails to provide adequate pain control. Sedation from opiates can also limit respiratory therapies and arly mobilization. Thoracic epidural analgesia has been used for many years to provide nalgesia for thoracic trauma, and published guidelines state that it is the preferred analgesic modality in patients with multiple rib fractures.[2] TEA, however, has a number of contraindications and potential complications, leading to the search for alternative analgesic options. Thoracic paravertebral blockade has been increasingly utilized for analgesia after thoracic surgery and more recently has been evaluated as an alternative to epidural analgesia for patients with multiple unilateral rib fractures. While epidural analgesia has long been considered the gold standard in managing rib fracture pain, retrospective studies have shown inconsistent benefit when compared to other analgesic modalities. In a 2009 meta-analysis including 232 patients from randomized controlled trials, TEA did not significantly impact mortality or ICU or hospital length of stay.[3] When only trials using TEA with local anesthetics were evaluated, epidural analgesia decreased duration of mechanical ventilation but at the expense of an increased incidence of hypotension. A more recent retrospective cohort study included 100 patients from 69 hospitals in the National Study on Cost and Outcomes of Trauma database; patients with three or more rib fractures receiving an epidural catheter had reduced mortality at 30, 90, and 365 days.[4] Thoracic paravertebral blockade has long had proven efficacy in reducing post-thoracotomy pain, and studies comparing TPVB to TEA have consistently been favorable. A 2014 meta-analysis showed equivalent pain scores at rest and with activity/coughing with reduced incidences of hypotension and urinary retention.[5] In a 2014 randomized controlled trial comparing continuous paravertebral infusion to thoracic epidural analgesia, the authors found improved pain control and increased forced expiratory volume in once second (FEV1) and room air oxygen saturations.[6] Side effects such as hypotension, rinary retention, and nausea and vomiting occurred only in the TEA group. Unfortunately, there are only limited data evaluating TPVB for treatment of pain resulting from chest trauma. In a randomized pilot study from 2009 comparing continuous thoracic paravertebral infusion to TEA for analgesia for patient with at least three unilateral rib fractures, there was no difference in analgesic efficacy, pulmonary complications, or ICU or hospital length of stay.[7]

<u>Side effects/complications of
thoracic epidural analgesia and paravertebral blockade</u>

Side effects from thoracic epidural analgesia are well known to most anesthesiologists and include hypotension, urinary retention, nausea and vomiting, and pruritus. All occur much less commonly with thoracic paravertebral blockade; with unilateral block, hypotension develops at 1/10 the frequency of TEA. In many studies, respiratory function is improved with unilateral TPVB. The reason for this is not completely clear; contributors likely include preservation of contralateral intercostal muscle function as well as decreased need for fluid administration given the lower incidence of hypotension. The only complications manifested more frequently with TPVB are pleural puncture and pneumothorax; with landmark techniques, these may occur in up to 1 and 0.5% of patients respectively.[8] The incidence with ultrasound guidance is unknown though thought to be significantly lower. The most devastating complications of epidural analgesia are epidural hematoma and epidural abscess, which on rare occasion may result in permanent neurologic deficits. Estimates of the incidence of epidural hematoma vary widely. Traditional estimates had been as low as 1 in 150,000 patients after placement of an epidural catheter, but newer evidence has suggested a significantly higher risk in certain populations. A study of 62,450 patients from centers participating in the Multicenter Perioperative Outcomes Group found an incidence of hematoma requiring surgical evacuation in nonobstetric patients of 1 in 8921.[9] Unfortunately, there are few investigations examining the frequency and severity of hemorrhagic complications after peripheral nerve blockade and none focusing on paravertebral blocks.

Anticoagulation and TEA/TPVB

When evaluating a patient receiving antithrombotic therapy for possible nerve block, most U.S. anesthesiologists refer to the American Society of Regional Anesthesia (ASRA) Evidence-Based Guidelines published in 2010.[10] The details are beyond the scope of this review, but the majority of the document focuses on risks and contraindications for neuraxial blockade. Though contiguous with the epidural space, the paravertebral space is larger and more distensible, making nerve compression causing permanent injury much less likely than with epidural analgesia. While only a handful of published case reports regarding complications from thoracic paravertebral block exist, there are no documented incidences of permanent neurologic injury from hematoma in the paravertebral space. Despite this, the ASRA guidelines recommend following the same conservative strategy as with neuraxial techniques. This recommendation is not universally accepted, as some authorities advocate relaxing anticoagulation contraindications, allowing TPVB to be a viable therapeutic option at times when neuraxial block is ruled out. The proliferation of new antithrombotic agents makes decision making even more difficult. Anesthesiologists are now seeing patients on medications such as dabigatran, a direct thrombin inhibitor, and rivaroxaban, a factor Xa inhibitor; both are prescribed for the prevention of stroke in nonvalvular atrial fibrillation and prophylaxis against postoperative venous thromboembolism. Though there are no consensus guidelines, many experts recommend stopping dabigatran 2-4 days before surgery with a high risk of bleeding or where major bleeding would be potentially catastrophic and for at least 5 days if creatinine clearance <30mL/minute. If available, a normal thrombin time confirms resolution of antithrombotic effect. Unfortunately, there are no formal recommendations regarding timing of discontinuing rivaroxaban. As its half-life is similar to dabigatran, it seems reasonable to follow the same preoperative recommendations. Monitoring of anticoagulation status can be done by following anti-Xa levels. If a neuraxial technique is being considered, the ASRA guidelines recommend only a “cautious approach.” Thus, anesthesiology groups must decide on their own standards with most following the preoperative discontinuation timing. Neither agent can be directly reversed; prothrombin complex concentrate (factor IX complex) and factor VIIa can be considered in the case of life threatening bleeding refractory to other management strategies, though there is no human evidence demonstrating clinical effectiveness.

Similarly, indications for cardiovascular stenting continue to increase, leading to a concomitant rise in the number of patient on antiplatelet therapy such as clopidogrel or prasugrel. The literature regarding neuraxial catheter placement in the setting of antiplatelet agents is sparse, and patient responsiveness to these medications and recovery of platelet function after their discontinuation is quite variable. Therefore, assessment of platelet function may be more clinically relevant than dosing history in determining risk. A number of point of care platelet function tests have been developed to assist clinicians in decision making in the perioperative period. Whole blood or light scattering platelet aggregometry are considered the gold standards but are expensive, require technical expertise, and may not be readily available. In a recent case report, thromboelastography (TEG) was used to reassure anesthesiologists of normal platelet function before removing an epidural catheter in a patient who had recently received antiplatelet medications.[11] Though the patient suffered no complication, standard TEG and rotational thromboelastometry (ROTEM) are insensitive to most causes of drug induced platelet dysfunction as thrombin present in the assay cups generated through the intrinsic coagulation pathway will activate platelets even in the presence of COX-1 inhibitors (such as aspirin) or thienopyridines (such as clopidogrel or prasugrel).[12] Modified or platelet mapping TEG and ROTEM require multiple channels and expensive reagents but can accurately assess platelet function. There are multiple case reports of using platelet function assays before safely placing or removing paravertebral or epidural catheters but no larger studies, so clinicians must still weigh the risks and benefits of intervention before violating consensus guidelines.

<u>Thoracic paravertebral block anatomy and technique</u>
Paravertebral blockade is achieved by depositing local anesthetic around nerve bundles as they exit the intervertebral foramina. The thoracic paravertebral space is wedge shaped and bordered by the vertebral body and disc medially, the superior costotransverse ligament posteriorly, and the parietal pleura anterolaterally. The space communicates with the intercostal space laterally and the epidural space medially via the intervertebral foramina. The first thoracic paravertebral block was performed in 1905, but its use escalated when the loss of resistance technique was first described in 1979. Clinical success has varied, likely due the difficulty in confirming proper needle placement. The introduction of ultrasound has revolutionized paravertebral block technique; multiple anatomic studies comparing ultrasound guided to and mark based loss of resistance methods have confirmed much higher rates of correct needle and catheter placement. Various ultrasound techniques have been described. TPVB can be performed with the patient sitting or lying in the lateral position with the side to be blocked uppermost. After determining the level to be blocked, a low frequency probe can be placed in either transverse or parasagittal orientation relative to the spinous processes. A few studies suggest that transverse probe orientation with the block needle advanced in-plane from lateral to medial and/or the catheter advanced in the same direction results in a higher incidence of epidural spread of local anesthetic and catheter tip malposition in the epidural space.[13,14] When the probe is oriented parasagitally, it should be 2-4 centimeters lateral to the spinous processes. Some clinicians utilize an in-plane technique, but this can be difficult given the depth of the paravertebral space and relatively small space between the transverse processes. When selecting an out-of-plane technique, hydrodissection is used to localize the needle tip. Once the needle is correctly placed anterior to the costotransverse ligament, hydrodissection is repeated; correct location is confirmed with anterior displacement of the parietal pleura. With periodic negative aspiration for blood, local anesthetic is slowly injected. A large volume (at least 10mL) injectate will provide analgesia for the level at which it is injected and usually spread at least 1-2

dermatomes cranial and caudal; if multiple dermatomes need to be covered, a multiple injection technique is recommended, keeping in mind the maximum safe dose of local anesthetic. Catheter placement is similar but requires a larger introducer needle; a Tuohy epidural kit may be used. Once the needle is confirmed in the correct location, 5-10mL of either saline or local anesthetic can be used to open up the space followed by introduction of the catheter. Of note, a thoracic paravertebral catheter may also be placed under direct vision by a surgeon during thoracotomy or thoracoscopy. As with single injections, multiple catheters may be required; usually 1 catheter is required for every 3-4 rib fractures covered.

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