22 Acute Situations: Trauma in Surgical Specialties

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Overview

Trauma is a major cause of mortality and morbidity worldwide, and pain is the most common symptom reported by patients entering the Emergency Department [1]. Each year, more than 100,000 deaths in the USA and about 8% of all deaths worldwide are caused by traumatic injuries [2]. Trauma is also a leading cause of death in persons younger than 30 years [3]. An estimated 5.3 million people in the United States have long-term disabilities resulting from traumatic brain injuries and another 200,000 from spinal cord injuries [3].

Among all the treatment modalities for trauma patients, pain management has become the core intervention because improved pain management has not only led to increased comfort in trauma patients, but has also been shown to reduce morbidity and improve long-term outcomes [4, 5]. Conversely, inadequate pain control leads to drastic clinical consequences, such as thromboembolic and pulmonary complications, lengthy hospital stay, and development of posttraumatic stress disorder [6–8]. Since trauma patients usually experience significantly more stress than patients undergoing elective surgery, trauma patients tend to have increased morbidity as a result of stress-induced higher myocardial oxygen consumption if pain is not adequately controlled [9]. It has also been shown that the persistence of severe, uncontrolled pain can lead to series of anatomic and physiologic changes in the nervous system [10]. These neuroplastic changes underlie the development of chronic, disabling neuropathic pain. For example, one study [11] reported that inadequate pain control resulted in chronic pain syndromes in 69% of patients with spinal cord injuries.

Unfortunately, multiple studies have reported that trauma-related pain is still inadequately controlled [12]. A recent study by Whipple et al. [13] assessed adequacy of pain treatment in 17 patients with multiple trauma injuries. While 95% of staff and 81% of nurses reported adequate analgesia, 74% of patients rated their pain as moderate to severe. Lack of recognition of pain and its related symptoms, limited acknowledgment of various pain management approaches, excessive concern about narcotics-induced hemodynamic instability, respiratory depression, and addiction all contribute to the inadequacy of pain management in trauma patients.

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Therefore, pain management in trauma patients still remains a challenge to clinical practitioners. Plus, the need to preserve the hemodynamic stability, the respiratory function, and patients' level of consciousness in this patient population further complicates the challenge.

Traumatic injuries can be associated with severe blood loss and coagulation derangements. Hemorrhage might not be evident at first, and especially in young patients, onset of hypotension is subtle and might not appear until >30% of blood volume is lost. Early signs of significant blood loss are low pulse pressure (less than 25% of the systolic value) and tachycardia with heart rate above 120 [14]. Long bone and pelvic fractures are associated with significant bleeding: a fractured femur, for example, can lead to a 2 L blood loss into the thigh. Blunt abdominal trauma can also lead to hemorrhagic shock, even if not evident at first (e.g., delayed splenic rupture).

Besides, up to one-third of trauma patients develop an endogenous coagulopathy very early in the clinical course [15]. This is a multifactorial condition that results from a combination of bleeding-induced shock, tissue injury with thrombin-thrombomodulin-complex generation, and the activation of anticoagulant and fibrinolytic pathways.

When choosing the optimal pain management protocol for the trauma patient, and even more so when regional anesthesia techniques are being considered, one must take into account that, although not apparent upon the patient's arrival, hemodynamic instability and coagulopathy might develop.

Multimodal analgesia has been increasingly used to manage pain in trauma patients [16]. This wide range of measures includes regional anesthesia procedures, opioids, NSAIDs, NMDA receptor blockers, anticonvulsants, antidepressants, and α2-agonists. Although each modality has its own strength and weakness, regional anesthesia, e.g., peripheral nerve blocks, stands out as an important technique especially in the perioperative setting because many traumatic injuries eventually require surgical interventions [3]. Regional anesthesia can become the first choice of analgesia in patients with isolated orthopedic injuries and burning injuries because this technique avoids many adverse side effects associated with systemic opioids, such as nausea/vomiting, pruritus, urinary retention, hypotension, and respiratory depression.

Even though evidence that shows improvement of outcomes by regional anesthesia in trauma patients is still lacking, it is generally agreeable that adequate analgesia via regional anesthesia reduces incidence of intubation and postoperative morbidity related to traumatic injuries, resulting in positive outcomes [17].

Any regional anesthesia techniques applicable in the elective surgery patient are potentially useful in the trauma patient. Nevertheless, the challenges to manage both pain and other trauma-related complications simultaneously require clinicians to take into account all possible risks and benefits of this technique in order for an optimum patient care to be achieved.

Peripheral Nerve Blocks for Pain Management in Trauma to the Extremities

Peripheral nerve blocks (PNBs) provide rapid and effective analgesia with less opioid-related side effects, such as nausea/vomiting, pruritis, urinary retention, constipation, sedation, and respiratory depression [18].

Depending on the site of injury and the planned operative procedure, peripheral nerve blocks should only be in a designated clinical context.

Before placing the block, it is very important to perform a neurological exam of the patient, documenting sensory and/or motor impairments [3]. A preexisting neurological injury does not represent per se an absolute contraindication to peripheral nerve blocks, but it is important to document it both for medicolegal reasons and for considerations in developing a clinical plan of treatment. Continuous peripheral nerve blocks have been shown to decrease pain scores, increase joint range of motion, and decrease hospital stay and rehabilitation times compared to intravenous patient-controlled analgesia [19]. They also produce fewer side effects compared with epidural analgesia [20].

Continuous infusion of local anesthetics through implanted catheters has often been found necessary in order to manage trauma-induced pain because single injections do not usually provide long enough pain coverage [3]. Ideally, regional techniques should initially be used to diminish the inflammatory response caused by tissue injury and then continue as long as the painful insults persist [21]. This "preventive" strategy, as opposed to preemptive analgesia which, by definition, only covers the earliest phase of the inflammatory insult, has been postulated to be more beneficial in terms of preventing chronic pain syndromes, although clear evidence is still lacking. In this perspective, multiple sequential catheters are sometimes indicated in order to provide optimal long-lasting analgesia [22]. This strategy has been successfully applied in military medical care, especially for soldiers wounded in combat [14].

Since trauma can occur at multiple sites, nerve blocks at multiple sites are often necessary in order to effectively reduce the amount of IV opioids required. It has been demonstrated that trauma patients may safely benefit from multiple simultaneous continuous peripheral nerve catheter infusions to treat multiple injuries [18].

Both peripheral nerve stimulation and ultrasound may be used to guide needle placement for peripheral nerve localization: neither technique has been proven to be superior to the other in terms of block success, although ultrasound may potentially decrease the time and number of attempts to complete a block [23]. Moreover, eliciting an evoked motor response across a fractured site may cause increased pain, and ultrasound brings a certain advantage in this setting [3]. In cases of traumatic nerve injuries, ultrasound has obvious indications and benefits [24].

Upper Extremity Trauma

Patients frequently presenting to the Emergency Department (ED) with upper extremity injuries such as fractures, dislocations, lacerations, and burns often require immediate pain relief provided by peripheral nerve block. Brachial plexus block usually provides adequate analgesia for upper extremity injuries. Depending on the injury sites, different approaches can be used, for example, interscalene, supraclavicular, or axillary blocks should provide effective pain relief for injuries at mid-distal arm, elbow, forearm, and/or hand [25]. Alternatively, various blocks at forearm should deliver adequate analgesia for hand or wrist injuries.

These nerve block approaches, however, are sometimes associated with risks of having various complications. For example, interscalene nerve block, which is often indicated for anesthesia and/or analgesia in patients with shoulder injuries, can cause Horner's syndrome that obscures the neurological assessment of the patients' consciousness level [3]. Accidental phrenic nerve block can result in an impairment of the ipsilateral diaphragmatic function [26]. The interscalene approach can also present an increased risk of infection should tracheostomy be performed or internal jugular vein catheter be implanted [3]. It is also known that both supraclavicular and infraclavicular nerve blocks are associated with pneumothorax [27]. Among these different approaches, axillary nerve block is probably the least desirable because it requires the largest scale of movement of the injured upper extremity and catheter positioning, and maintenance becomes difficult under the arm [3].

Use of ultrasound in upper extremity nerve blocks has improved the accuracy of needle insertion and catheter placement. The advantage of ultrasound-guided nerve block becomes obvious when it is hard to locate skin landmarks due to either excessive adipose tissues or anatomic distortions caused by neck injuries. It is noteworthy that the presence of C-collar is not a contraindication to performing upper extremity nerve blocks. Once cervical traumatic injuries are ruled out by proper imaging tests, C-collar can be removed and an ultrasound-guided nerve block can be performed.

Sympathectomy that follows regional anesthesia of the upper extremity is often beneficial for revascularization, reimplantation, or in any

Table 22.1 Principal upper extremity blocks in trauma

Upper extremity blocks			
	Indications	Pro	Cons
Interscalenic	Shoulder, proximal humerus,	Effective analgesia with low volume of anesthetic Possibility of continuous block	Ipsilateral diaphragmatic paralysis Risk of vascular puncture
Supraclavicular	Distal humerus, elbow, forearm, wrist	Effective analgesia with low volume of anesthetic Possibility of continuous block	Risk of pneumothorax and vascular puncture
Infraclavicular	Distal humerus, elbow, forearm, wrist	Effective analgesia with low volume anesthetic Lower risk of pneumothorax compared to supraclavicular Possibility of continuous block	Risk of pneumothorax and vascular puncture in non-compressible site
Axillary	Distal humerus, elbow, forearm, wrist	Safest: no risk of pneumothorax, vascular puncture in compressible site	Need for appropriate patient positioning More painful (multiple needle directions) Only single shot block possible

other cases where blood flow is compromised [28]. Before performing the block, the risks and benefits should be discussed with the surgeon. Every effort should be made to avoid radial compartment syndrome. If necessary, a short-acting local anesthetic may be preferred and can be used reliably for surgical anesthesia.

See Table 22.1 for an overview of indications, pro, and cons of upper extremity blocks in trauma.

Case Study #1

A 76-year-old lady is brought to the ED after a fall while riding her bicycle. She is diagnosed with a displaced comminuted left humeral head fracture, and scheduled for surgery the following day. She has moderate Chronic Obstructive Pulmonary Disease (COPD) and her medications include Bronchodilators and low dose Aspirin. She is in considerable pain at rest (NRS 6), which becomes unbearable upon mobilization (NRS 10). Discuss the options for pain management in this patient.

Discussion

Continuous interscalene block is a good option for this patient. An eco-guided procedure should be preferred, in order to avoid the intense pain associated with nerve stimulation in a fractured limb. This block provides good analgesia to the shoulder, upper arm, and elbow. Since the patient is scheduled for surgery, placing a perineural catheter allows to prolong analgesia into the intra- and postoperative period. Interscalene block is associated with phrenic nerve block and consequent ipsilateral hemi-diaphragm paralysis: for this reason it is generally contraindicated in patients with severe pulmonary disease, but should not be a major concern in a patient with moderate COPD. Cautious evaluation should be undertaken in trauma patients with ipsi and contralateral pleural effusions, pulmonary contusions, and pneumonia.

Case Study #2

A 20-year-old boy suffers a displaced fracture of his right forearm after a skateboard accident. He is in considerable pain and is very concerned about the planned reduction maneuver. A conservative treatment is planned, and he will be discharged home with a cast. Discuss the options for pain management in this patient.

Discussion

If a regional anesthesia technique is chosen, single shot supraclavicular, infraclavicular, and axillary block are all good options. The latter avoids the risk of pneumothorax, but the required position with the abducted arm might be difficult to sustain for the patient. Again, we recommend echo-guided technique and avoidance of neural stimulation. Before discharge, the patient should be informed on the planned duration of the block, and instructed to seek medical advice if numbness/paresthesia persist beyond a reasonable time. An oral analgesic prescription (Acetaminophen or NSAID) should also be provided for the following days.

Lower Extremity Trauma

Regional anesthesia at lower extremity usually includes lumbar plexus block and sacral plexus block at different sites. These nerve block procedures have been proved superior over morphine PCA in providing analgesia in patients with lower extremity trauma [29, 30]. They are also considered safer with less complications comparing with epidural block [3].

Lumbar plexus can be blocked using either anterior or posterior approaches. Anterior approaches at the level of inguinal ligament (3-in-1 or fascia iliaca blocks) have the obvious advantage of not having to put the patients in the lateral position, and have been demonstrated to be safe and at least equivalent to intravenous analgesia in reducing pain in both adult and pediatric patients with femur fractures [31, 32]. The downside is that bocks at this level do not effectively cover all the branches of lumbar plexus, and larger volumes of local anesthetics are often needed to provide adequate analgesia [33].

Posterior approaches (psoas compartment block) usually provide excellent analgesia [34] with relatively small dose of local anesthetics because adequate coverage of all lumbar plexus branches can be achieved at the level of psoas muscle compartment.

Various approaches to sacral plexus block have also been used to provide analgesia to where sciatic nerve is distributed.

Depending on the injury sites, either lumbar plexus or sacral plexus or both have to be used to warrant adequate analgesia. For example, acetabular or femoral neck injury may only require a lumbar plexus block, whereas knee/patellar injuries and ankle injuries require both femoral and sciatic nerves to be blocked [3].

Complications from continuous lower extremity nerve blocks are rare, although minor events like local inflammation and vascular puncture may be common [35]. The incidence of infection associated to nerve blocks is poorly defined in literature, and even if the rate of catheter tip contamination results between 23 and 57%, the incidence of clinical local infections is only 0–3% [3].

Among these complications, it is worth noting that psoas compartment block could lead to epidural and/or intrathecal injection of local anesthetics either due to catheter displacement or local anesthetic spread resulting in bilateral block and hypotension [34]. The risk of neuraxial block may be lowered by avoiding medial direction of the needle when psoas compartment block is performed.

See Table 22.2 for an overview of indications, pro, and cons of lower extremity blocks in trauma.

Table 22.2 Principal lower extremities blocks

Lower extremity blocks			
Psoas Compt. Lumbar plexus block	Hip, femur, knee fractures	Effective analgesia with low volume of anesthetic, possibility for continuous block	Need for lateral decubitus Possible peridural spread of anesthetic Possible vascular puncture in non compressible site
Fascia iliaca, 3 in 1 block, Femoral block	Hip, femur, knee, ankle fracture	Patient in the supine position, superficial blocks	Not all branches effectively blocked, may require larger volume of anesthetic or intravenous top-up
Sciatic block	Hip, leg, ankle fractures	Can be performed at different sites, effective analgesia with low volume of anesthetic, possibility of continuous block	As all peripheral nerve blocks, may mask compartment syndrome or neurological injuries

Case Study #3

A 50-year-old woman reports a right spiral femur shaft fracture after a ski accident. Her medical history includes hypertension and moderate chronic renal failure due to nephroangiosclerosis. She reports moderate pain at rest (NRS 5), and severe pain upon mobilization (NRS 10). She is scheduled for surgery on the following day. Discuss the options for pain management in this patient.

Discussion

Continuous lumbar plexus block at the psoas compartment is likely to be a very effective option for perioperative pain management in this patient, since it would provide effective analgesia for the pre-, intra-, and postoperative period. However, the patient has unbearable pain at mobilization, and muscle twitches associated with nerve stimulation is likely to cause great discomfort. Eco-guided Fascia Iliaca block might represent a valid alternative, since it can be performed in the supine position. The sensory block provided by fascia iliaca block is not as intense as with lumbar plexus block, and additional spinal or general anesthesia will be required for surgery.

Case Study #4

A 22-year-old male basketball player has to undergo reduction of a trimalleolar ankle fracture, and surgical repair is scheduled for the following days. Discuss the possible analgesic plan for this patient.

Discussion

Pain from trimalleolar ankle fracture is usually very intense, and peripheral nerve block is indicated. Femoral and Sciatic Bi-block will be necessary to provide complete analgesia and intraoperative anesthesia of the ankle. Femoral nerve block provides anesthesia of the medial aspect of the ankle, and can be maintained on a bolus-based fashion if total local anesthetic dose is a concern. Continuous sciatic block will cover the remaining of the surgical site.

Acute Compartment Syndrome

In lower extremity musculoskeletal trauma, acute compartment syndrome is a potentially devastating complication, whose incidence has been previously described as 7.3 per 100,000 in men and 0.7 per 100,000 in women [36]. The most common cause of acute compartment syndrome is usually fracture (69%) with tibial fracture being the most common injury; soft tissue injury without fractures is the most common cause (23%) with 10% of these occurring in patients taking anticoagulants or with a bleeding disorder [37]. Pain out of proportion to the injury, aggravated by passive stretching of muscle groups in the corresponding compartment, is one of the earliest and most sensitive clinical signs of compartment syndrome, even though it can be diminished or absent in an established compartment syndrome [38]. Anesthetic techniques have been reported to contribute to delay of the diagnosis [39]. Patients receiving epidural analgesia with local anesthetics and opioids have been reported to have a fourfold increased risk of neurologic complications than patients receiving systemic narcotics [40]: epidural analgesia with local anesthetics and opioids is therefore not recommended in at-risk patients. However, in the trauma patient, the absence of pain in a compartment syndrome is often caused by superimposed central or peripheral neural deficit, and pressure or firmness in the compartment remains the earliest and sometimes the only objective finding of early compartment syndrome [37]. Various methods of measuring tissue pressure have been described [41], and their application is recommended any time the clinical picture may be borderline or the patient examination can be ambiguous. In this scenario, a peripheral nerve block is not absolutely contraindicated, and each specific case should be addressed and discussed with the trauma team.

Case Study #5

A 25-year-old male soccer player is brought to the emergency department after a sport accident. He is diagnosed with tibial shaft fracture, with no associated injuries. Neurological examination, although impaired by intense pain, reveals mild hypoesthesia of the toes and weakness on toe extension. Calcaneal skeletal traction is placed and the patient is scheduled for surgery on the following day. Intramedullary nailing is performed under general anesthesia, and is uneventful. On postoperative day 1, unbearable leg pain, paresthesia of the toes and frank motor deficit upon toe extension develop, the skin of the anterior leg compartment looks very tight and tissue pressure measure raise a high suspicion for acute compartment syndrome. Emergency fasciotomy is performed and the patient slowly recovers during the following days. At 3 months, he shows no signs of motor or sensory neurological deficit. Discuss the role of regional anesthesia for this patient.

Discussion

This patient presents several risk factors for acute compartment syndrome development (young athlete, sport injury, tibial shaft fracture). Furthermore, some degree of neurological impairment is already present upon admission. Regional anesthesia is not absolutely contraindicated in this setting, but the possibility that peripheral nerve block may mask or delay the diagnosis of ACS should be always kept in mind. If a perineural sciatic catheter block is inserted for continuous analgesia, it may be advisable to use a short-acting local anesthetic at low concentration (e.g., mepivacaine 0.5%) for continuous infusion, or a protocol based on discrete boluses, which can be administered by care-givers after physical and neurological examination.

Peripheral Nerve Blocks for the Management of Chest Trauma

Rib fractures are the most common thoracic injuries with an incidence ranging from 10% to almost 30% in patients after trauma. Mortality rate of patients with rib fractures range from 5.8% (single rib fracture) to 34.4% (multiple rib fractures) with an overall rate of 10%. Pain associated with rib fractures usually impairs pulmonary function and increases pulmonary morbidity. Therefore, appropriate pain management in a timely manner should be a core intervention in managing these patients. Various techniques have been used to manage pain in patients with rib fractures. These include systemic opioids, intercostal nerve blocks, epidural analgesia, and intrapleural and paravertebral nerve blocks. Clear superiority of one technique over the others in terms of efficacy and safety has not been demonstrated in the literature.

Intercostal Nerve Block

Both multiple single-shot injections with local anesthetics above and below the fracture site and continuous intercostal infusions have been shown to be successful in relieving pain caused by rib fractures. However, the exact mechanism underlying the intercostal analgesia is still unknown. Anesthetics are supposed to spread to the paravertebral space, epidural space, or a combination of both. An early case report showed paravertebral spread of local anesthetic after 20 mL of 0.5% bupivacaine was injected into the intercostal space. The same mechanism was confirmed by Mowbray et al. [42], who followed the spread of intercostal injection of 20 mL of bupivacaine and methylene blue through a catheter at thoracotomy in the paravertebral space. Indeed, a recent study verified a paravertebral catheter placement through the intercostal space. Therefore, it is possible that the major component of segmental block during intercostal catheterization may be secondary to paravertebral spread.

Intrapleural Nerve Block

There are many reports of the successful use of unilateral and bilateral interpleural blockade in patients with multiple rib fractures. This technique produces multi-segmental intercostal nerve blockade by gravity-dependent retrograde diffusion of the local anesthetics to reach the intercostal nerve. A few studies have compared the interpleural nerve block with epidural block, paravertebral nerve block, and conventional opioids for analgesic efficacy in chest wall trauma with contrasting results. Some reasons for the conflicting results include catheter position, presence of hemothorax, location of fractured ribs, characteristics of local anesthetics, loss of local anesthetic through chest tubes, and dilution in pleural effusion. Among these reasons, it is interesting to notice that the location of rib fractures may affect the analgesic efficacy by interpleural nerve block. It appears that interpleural nerve block is most useful in clinical settings such as lateral or posterior rib fractures in the healthy chest cavity.

Epidural Nerve Block

Many studies have shown that thoracic epidural nerve block with local anesthetics, opioids, or a combination of both produces dramatic analgesia in patients with multiple rib fractures. Pulmonary function such as functional residual capacity, forced vital capacity, airway resistance, maximal inspiratory force, and maximal tidal volume is also reported improved by epidural analgesia. Although evidence that epidural nerve block improves subjective pain score and a variety of pulmonary functions in rib fracture patients is abundant and compelling, there is limited evidence that epidural nerve block improves outcomes. In a meta-analysis by Carrier et al. [43], evaluating seven randomized controlled studies (232 patients), epidural analgesia did not demonstrate significant benefits related to mortality, ICU length of stay, hospital length of stay, or duration of mechanical ventilation compared to other analgesia modalities, including opioid PCA or IV/IM opioid boluses and interpleural nerve blocks. Moreover, hypotension proved to be more frequent in patients receiving epidural analgesia. Thus, the evidence does not support the strength of the recent clinical practice guidelines on pain management in blunt thoracic trauma laid out by the East Association for the Surgery of Trauma (EAST), which stated that epidural analgesia may improve clinically significant outcomes in this population (Grade B recommendation) and that it should be considered the preferred analgesic modality (Grade A recommendation). In addition, in patients with mechanical ventilation and sedation, epidural analgesia is usually relatively contraindicated because of the patients' altered level of consciousness. Therefore, considering the potential for rare but major adverse events of epidural nerve block, clinically significant benefits other than better pain control need to be demonstrated to endorse the use of epidural nerve block as a standard of care in adult patients with traumatic rib fractures.

Paravertebral Nerve Block

Paravertebral nerve block is a regional anesthetic technique in which a single injection of anesthetic or a continuous infusion is delivered to the thoracic paravertebral space, producing a unilateral, multilevel, somatic, and sympathetic block. Since it is simple to perform, is associated with a low incidence of complications, requires no additional nursing surveillance, and has few absolute contraindications, paravertebral nerve block has recently been used to control pain in a variety of conditions involving the chest and abdomen. Evidence is also accumulating in support of this modality in patients with trauma, such as rib fractures: single injection of 0.5% bupivacaine into the thoracic paravertebral space led to significant improvement of pain scores and vital capacity in patients suffering from blunt or penetrating thoracic trauma; continuous paravertebral anesthetic (0.5% bupivacaine at 0.1–0.2 mL/kg/h for 4 days) in 15 patients with isolated unilateral rib fractures also provided significant improvements in analogue pain scores, vital capacity, peak expiratory flow rate, oxygen saturation (SaO_2), and O_2 index (PaO_2/FiO_2 ratio). Compared with epidural nerve block, paravertebral nerve blocks have been shown to produce comparable pain relief and similar improvements in respiratory function in patients with unilateral fractured ribs, although epidural was complicated by a higher incidence of hypotension. A downside of paravertebral nerve blocks is that fewer practitioners are familiar with the technique, and large clinical trials are still lacking in the trauma population. Nevertheless, an increasing availability of data in the literature supports their efficacy in other clinical scenarios such as thoracotomies, which share a common pain mechanism with rib fractures, that is, intercostal nerve damage. Preoperative paravertebral nerve blocks have been demonstrated to significantly lower postoperative pain scores and better preserve postoperative lung function, measured by forced vital capacity, when compared to epidural analgesia. Moreover, a few review papers reported that paravertebral nerve block provided at least equally effective analgesia to epidural with fewer side effects, such as urinary retention, nausea/vomiting, and hypotension. Moreover, while epidural technique is contraindicated in the setting of coagulopathy due to the risk of hematoma and subsequent cord compression, the margin of safety is much higher with a paravertebral block and the more distensible paravertebral space.

See Table 22.3 for an overview of indications, pro, and cons of locoregional techniques in thoracic trauma.

Case Study #6

A 67-year-old male pedestrian is brought to the emergency department after being run over by a car. Medical history reveals hypertension and chronic atrial fibrillation treated with Warfarin. He reports a ruptured spleen and multiple (6th to 10th) left rib fractures with pneumothorax. After anti Vitamin K reversal with Prothrombin Complex Concentrate and chest tube positioning, he undergoes emergency splenectomy. During surgery he develops mild hypotension that is treated with crystalloids and transfusion of 3 Units of Red Blood Cells. On POD 1, despite endovenous analgesia with acetaminophen, NSAIDs, and morphine, he reports severe thoracic pain at inspiration, which limits chest expansion to shallow breathing, and becomes unbearable with deeper inspirations. Discuss alternative pain management options for this patient.

Discussion

This patient would certainly benefit from thoracic peridural catheter positioning. However, there are some concerns regarding this choice in this particular setting. The patient has suffered considerable blood loss and might still be at risk for developing hypotension with epidural analgesia. Careful titration with a short-acting local anesthesia may be warranted. Moreover, this patient will have to resume oral or subcutaneous (Low molecular Weight Heparin, LMWH) anticoagulant therapy for chronic atrial fibrillation. This is not an absolute contraindication for epidural catheter placement, with strict adhesion to correct timing between LMWH administration and catheter positioning/removal. Continuous paravertebral block may be a suitable alternative in this case, where hypotension and coagulopathy are major concerns. The same recommendations regarding catheter handling and anticoagulant timing should be followed, but paravertebral block may carry a lower risk of spinal hematoma in the case of accidental catheter removal. Other suitable alternatives are intrapleural block and intercostal nerve block, the latter being less desirable since it would require several injections to cover pain from multiple fractures.

Table 22.3 Principal blocks in thoracic trauma

Thoracic blocks			
Epidural	Rib fractures Laparotomy	Effective analgesia for multiple and bilateral injuries, improvement of pulmonary function	Risk of hypotension, spinal hematoma, Motor block, nausea
Paravertebral block	Rib fractures	Effective analgesia, lower risks compared to epidural	Multiple injections required if bilateral injuries
Intercostal, Intrapleural	Rib fractures	Lower risks compared to epidural	Multiple injections required if bilateral injuries

Clinical Pearls

- Improved pain management has been shown to reduce morbidity and improve long-term outcomes.
- Multimodal analgesia has been increasingly used to manage pain in trauma patients; this wide range of measures includes regional anesthesia procedures.
- Peripheral nerve blocks (PNBs) provide rapid and effective analgesia with less opioid-related side effects, such as nausea/vomiting, pruritis, urinary retention, constipation, sedation, and respiratory depression.
- Brachial plexus block usually provides adequate analgesia for upper extremity injuries.
- Use of ultrasound in upper extremity nerve blocks has improved the accuracy of needle insertion and catheter placement. Its advantages become especially obvious when it is hard to locate skin landmarks.
- Regional anesthesia at lower extremity usually includes lumbar plexus block, fascia iliaca block, and sacral plexus block at different sites.
- The posterior approaches to the lumbar plexus usually provide excellent analgesia with relatively small dose of local anesthetics, while fascia iliaca block has the advantage of keeping the patient in the supine position. Various approaches to sacral plexus block have also been used to provide analgesia to where sciatic nerve is distributed.
- Pain associated with rib fractures usually impairs pulmonary function and increases pulmonary morbidity: appropriate pain management in a timely manner should be a core intervention in managing these patients.
- Pulmonary function such as functional residual capacity, forced vital capacity, airway resistance, maximal inspiratory force, and maximal tidal volume is reported improved by epidural analgesia in patients with chest trauma.
- Paravertebral nerve blocks have been shown to produce comparable pain relief and similar improvements in respiratory function than epidural analgesia in patients with unilateral fractured ribs, although epidural was complicated by a higher incidence of hypotension.
- Paravertebral nerve blocks provide at least equally effective analgesia to epidural with fewer side effects, such as urinary retention, nausea/vomiting, and hypotension in patients with chest trauma.

Review Questions

1. How many deaths in the USA are caused by traumatic injuries every year?
   (a) 100,000
   (b) 500,000
   (c) 1,000,000
   (d) 250,000
   (e) 25,000
2. Which percentage of deaths is caused by traumatic injuries worldwide?
   (a) 0.1%
   (b) 8%
   (c) 25%
   (d) 0.25%
   (e) 12%
3. In which percentage of patients' inadequate pain control resulted in chronic pain syndromes after spinal cord injuries?
   (a) 20%
   (b) 30%
   (c) 40%
   (d) 50%
   (e) 70%
4. In the recent study by Whipple et al. [13] about adequacy of pain treatment in patients with multiple trauma injuries, which percentage of patients rated pain as moderate to severe?
   (a) 24%
   (b) 10%
   (c) 0.2%
   (d) 74%
   (e) 99%
5. Which upper extremity block can have Horner's syndrome as a complication?
   (a) Axillary block
   (b) Infraclavicular block
   (c) Supraclavicular block
   (d) Interscalene block
   (e) Ulnar block at the elbow

6. In lower extremity musculoskeletal trauma, acute compartment syndrome is a potentially devastating complication, whose incidence has been previously described as:
   (a) 7.3 per 100,000 in men and 0.7 per 100,000 in women
   (b) 0.7 per 100,000 in women and 7.3 per 100,000 in men
   (c) 30 per 100,000 in men and women
   (d) 0.5 per 100,000 in men and 0.01 per 100,000 in women
   (e) 70 per 100,000 in men and women
7. The most common cause of acute compartment syndrome is usually:
   (a) Burn injury
   (b) Soft tissue injury
   (c) Fracture
   (d) Crush injury
   (e) Tissue edema
8. The most common fracture that can be complicated by compartment syndrome is:
   (a) Humerus fracture
   (b) Scaphoid fracture
   (c) Tibial fracture
   (d) Femur fracture
   (e) Scapular fracture
9. A predisposing factor for compartment syndrome in soft tissue injuries is:
   (a) Regional anesthesia
   (b) Hypertension
   (c) Anticoagulants or bleeding disorders
   (d) Hypotension
   (e) Vascular diseases
10. One of the earliest and most sensitive clinical signs of compartment syndrome is:
   (a) Pain out of proportion
   (b) Motor and sensory block
   (c) Paresthesia
   (d) Absence of pain
   (e) Pallor
11. Mortality rate of patients with single rib fractures is around:
   (a) 1%
   (b) 10%
   (c) 6%
   (d) 50%
   (e) 0.1%
12. Mortality rate of patients with multiple rib fractures is around:
   (a) 90%
   (b) 80%
   (c) 70%
   (d) 35%
   (e) 25%
13. The East Association for the Surgery of Trauma (EAST) stated that one of the following may improve clinically significant outcomes in this population (Grade B recommendation) and that it should be considered the preferred analgesic modality (Grade A recommendation):
   (a) Intrapleural block
   (b) Epidural block
   (c) Intercostal block
   (d) Paravertebral block
   (e) Morphine PCA
14. When compared to epidural, paravertebral nerve blocks have been demonstrated to cause less:
   (a) Hypotension and urinary retention
   (b) Failed block
   (c) Compartment syndrome
   (d) Foot drop
   (e) Infections
15. Which of the following have been demonstrated to provide comparable analgesia?
   (a) Intercostal and intrapleural blocks
   (b) Intercostal and paravertebral blocks
   (c) Epidural and intrapleural blocks
   (d) Paravertebral and epidural blocks
   (e) Paravertebral and intrapleural blocks

Answers

1. a
2. b
3. e
4. d
5. d
6. a
7. c
8. c
9. c
10. a
11. c
12. d

13. b
14. a
15. d

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