

Pain Management in the ICU

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KEYWORDS

• Pain • Regional anesthesia • ICU • Trauma • Rib fractures

KEY POINTS

- There are many sources of pain in the ICU requiring different considerations for treatment.
- Uncontrolled pain is associated with other detrimental system physiologic responses.
- Pain scales, when used, can provide guidance in treatment effectiveness.
- As in other areas of ICU care, nursing protocols for pain management can help improve the overall care and therapy of patients.
- Opioid and nonopioid analgesic therapies, although generally effective, also can be associated with significant morbidity and mortality.
- Regional anesthesia techniques are quite effective on patients in the ICU, elderly patients especially, and are generally underutilized.

INTRODUCTION

For the intensive care unit (ICU) practitioner, pain management has many unique considerations and challenges. Critically ill patients often have multiple systemic disease processes requiring rapid evaluations and changes in treatment plans. Further, many patients in the ICU are incapable of communicating clearly, either as a direct result of their injuries or illness or because of intubation and sedation requirements. Together, these circumstances make the assessment and treatment of potentially painful conditions difficult. In the ICU setting, there are myriad sources of pain, both disease related as well as from many of the therapies and treatments used to sustain and restore life. Sources of pain range from invasive procedures, surgeries, and placement of monitoring devices, to direct nociceptive stimuli from injury, inflammation, and immobility.¹⁻³

There are systemic effects produced by pain, and these may add to the physiologic insult of the patient in the ICU. Comprehensive treatment of pain can lessen these effects substantially.⁴⁻⁶ Pain affects all body systems through neurohormonal

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mechanisms, catecholamine release, sympathetic outpouring, and the general stress response (**Table 1**).⁷⁻⁹ Physiologic responses to pain include anxiety, tachycardia, diaphoresis, and catabolism. This results in increased myocardial oxygen demand, increased bowel motility, tachypnea, activation of the renin-angiotensin-aldosterone axis, and the production of a large number of cytokines. Further, it is also believed that pain may result in immune system dysfunction, hypercoagulable states, altered glucose control, patient-ventilator dyssynchrony, acute restrictive respiratory physiology, and disrupted sleep quality.^{4-7,10}

Consequent to these deep interactions between pain and other physiologic processes, it is critical that clinicians caring for these patients be knowledgeable in the assessment and management of pain. Despite the known issues relating to the lack of pain treatment, there exists a paucity of evidence-based data supporting treatment principles. Most data are extrapolated from other settings and transferred directly to the ICU, further complicating the care of these patients. This underscores the need for ICU clinicians to be facile in the understanding and management of pain in this setting.

PATHOPHYSIOLOGY OF PAIN

Definitions and Types of Pain

Pain is variably defined by different investigators and organizations over the past 100 years, although most recently the International Association for the Study of Pain has adopted what is now the most widely held definition: "Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage."¹¹ Although this definition serves to describe pain as a whole, it is helpful to classify pain based on its characteristics, both to better direct treatment and to assist research into specific pain states. To this end, the International Association for the Study of Pain has classified pain according to (1) region of

System	Effect
Immune/Inflammatory	Downregulated immunomodulation through cytokine release and leukocyte dysfunction (especially natural killer cells). Increased prostaglandin production from high cell turnover, muscle breakdown.
Cardiovascular	Increases in Vo_2 (oxygen consumption) through increased adrenergic tone.
Gastrointestinal	Decreased motility.
Renal	Anasarca through activation of the Renin-Angiotensin system.
Endocrine	Hyperglycemia and hypotension through dysregulation of cortisol and insulin. Increased catabolism.
Respiratory	Hyperventilation, ventilator dyssynchrony, lowered functional residual capacity, hypoxia.
Psychological	Depression, fatigue, psychosis, sleep deprivation, and anxiety through altered neurohumeral responses.
Hematological	Alterations in platelet function resulting in thromboembolic disease and gastrointestinal bleeding. Decreased mobility leading to increased risk of venous thromboembolism.

Adapted from Fishman SM, Ballantyne JC, Rathmell JP, editors. *Bonica's management of pain*. 4th edition. Philadelphia: Lippincott, Williams and Wilkins; 2010. p. 1589; with permission.

the body involved, (2) system experiencing the dysfunction, (3) duration and pattern of occurrence, (4) intensity and time since onset, and (5) etiology.¹² An additional category based on neurochemical mechanism has been proposed to augment this classification scheme for the purposes of guiding research and treatment.¹³ These definitions and classifications of pain are distinct from that of *nociception*, a term that refers merely to the sensory process that is triggered by the inciting event (although it may be maintained by different, distinct processes). From a clinical standpoint, it is useful to characterize the major subdivisions of pain as somatic, visceral, neuropathic, or mixed, as this is what is frequently used to help guide specific therapy.^{4,7}

In the ICU, pain originates primarily as a result of short-duration stimuli with or without some degree of chronicity. This pathophysiologic mechanism can simply be described as activation of the neural afferent (nociceptive) signals that have arisen from tissue damage. It is important to remember that the acute pain experienced by the patient in the ICU can be a manifestation of both the underlying illness or injury as well as iatrogenically derived pain from therapies, such as monitor placement, surgery, and immobility.^{1,2} Turning, in fact, is one of the most painful and distressing procedures endured by patients in routine ICU care.¹⁴ Further, patients can acquire chronic pain syndromes during an ICU stay, presumably from inadequately treated prolonged and/or repeated pain experiences.^{3,8}

For the ICU clinician, it is particularly helpful to divide pain into the subtypes most commonly seen in this setting: (1) acute postoperative or posttraumatic pain, and (2) neuropathic pain. This simple classification can serve to guide therapeutic approaches and is effective enough for use in the acute management of these patients. In the ICU, the subjective experience of pain by the patient is often limited by the patient's capacity to communicate. ICU pain is predominantly in the somatic domain. This type of pain is often described as dull and aching, is typically well localized, and is well suited to therapies including opiates and nonsteroidal anti-inflammatory agents (NSAIDs); medications that form the mainstay of ICU pain management. Visceral pain is often seen in the ICU setting and can arise from poor bowel care or from underlying gastrointestinal pathology. Opiates and NSAIDs typically do not work well for this subtype and anticholinergics should be considered if patients are not responding well to traditional somatic pain therapies. Neuropathic pain is less well documented in the ICU but deserves consideration, especially in those with prolonged stays or injuries directly involving neurovascular structures.

PAIN ASSESSMENT

Acute pain, when unrecognized and undertreated, has both physiologic and psychological implications affecting patient outcomes.^{15–17} Adequate and appropriate treatment and management of pain relies on a standardized, systematic approach to guide initiation and titration of therapy. Provider assessments (at both the physician and nurse level) of pain are typically underestimated¹⁸ and it is accepted that patient assessment of pain should guide therapy. In verbal, communicative patients, traditional pain scales can be used.^{19,20} In the ICU, however, patients are often unable to verbalize their pain or participate in traditional pain-assessment techniques. This may be because of respiratory status, mental status, iatrogenic sedation, multiple procedures, or a combination of all.²¹

Physiology-Based Scales

Although physiologic indicators can correlate with pain levels,²² caution should be taken with a physiologic-based treatment algorithm. Heart rate and blood pressure

increase with increasing levels of pain, but it should be recognized that these changes might occur for other physiologic (or pathophysiologic) reasons. Conversely, such changes in physiologic disturbances may be absent during periods of undertreated pain as well. Based on prior studies, it is recommended that the changes in vital signs described previously should be used to alert providers to the possibility of untreated or undertreated pain and further investigation is warranted.²³

Behavioral-Based Scales

With physiologic parameters proving unreliable for the assessment and treatment of pain in sedated or unresponsive patients, a large study was undertaken to describe behavioral abnormalities exhibited by patients in pain. The study examined behaviors in conscious patients with the assumption these same behaviors would likely be noted in unconscious patients.²⁴ The most commonly noted behaviors were grimacing, muscle rigidity, wincing, eye shutting, and fist clenching.

It was noted that nurses frequently used these behaviors to assess and treat pain, but in a nonsystematic approach that was difficult to study. Consequently, multiple pain scales have been developed incorporating these behavioral changes. These scales can be grouped into unidimensional and multidimensional. An unidimensional approach uses only 1 dimension (eg, behavioral, physiologic) but may use one or more domains (eg, wincing, eye shutting, grimacing) within that dimension. A multidimensional approach uses more than 1 dimension and any number of domains within those dimensions.²⁵ Studies have noted that self-reported pain measures correlate better with multidomain scales and that no single domain correlates well with self-reported pain scores.²⁶

Unidimensional Assessment Tools

The most common unidimensional assessment tools are the Behavioral Pain Scale (BPS), Pain Behavior Assessment Tool (PBAT), and the Critical-care Pain Observation Tool (CPOT). The BPS, the earliest and most widely tested pain assessment tool, uses 3 behavioral domains, each one graded on a 1 to 4 scale.²⁷ The validity of the BPS was shown with patients undergoing painful procedures scoring higher than those undergoing nonpainful procedures.²⁸ As such, it is a reliable, valid tool for pain assessment, but critics have cautioned that including movement as a behavioral domain may underestimate pain, as sedated patients may not exhibit excessive movement with painful stimuli.²² The PBAT includes 3 behavioral domains with several descriptors each. The CPOT is a unidimensional tool for both intubated and nonintubated patients. It relies on 4 behavioral domains with a point scale devoted to each.²⁹ Its notable strengths are its ease of use and dedication of descriptors to both intubated and nonintubated patients.

Multidimensional Assessment Tools

The most common multidimensional assessment tools are the Pain Assessment and Intervention Notation (PAIN) Algorithm, and the Nonverbal Pain Scale (NVPS). The PAIN Algorithm, originally designed for research, relies on 3 parts. It includes a pain assessment, an assessment of opioid tolerance, and a guideline for treatment decision and documentation.³⁰ Assessment uses 6 behavioral domains and 3 physiologic parameters. After consideration of these 9 fields, the severity is recorded on a 0 to 10 scale. This tool is criticized as being too long and cumbersome for clinical utility and has a lack of reliability testing in the literature.²² NVPS, originally designed for intubated, sedated burn victims, builds on the FLACC (Face, Legs, Activity, Cry, Consolability) platform constructed for children.³¹ Included in this assessment are both

physiologic and behavioral domains. The validity and reliability have been demonstrated in the literature.³²

Although feasibility, validity, and reliability were examined in most of these assessment tools, rigorous outcomes-based research is lacking. Further testing is required before any one of the tools can be considered preferred. Thus, no one of these methods is considered superior to any other and none should be regarded as the gold standard.

Outcomes of Algorithm-Based Analgesia Administration

Most current studies presented in the literature pertaining to algorithm-based analgesia administration are presented in combination with sedation. Separation of pain assessment from anxiety and delirium is difficult and not always clinically feasible. A formal discussion of sedation and delirium is beyond the scope of this article.

Gelinas and colleagues³³ studied preimplementation and postimplementation of the CPOT assessment tool examining the feasibility of nurse training, documentation, and an amount of pain medication administered. Improved documentation with an overall increase in the number of pain assessments was shown, whereas a decrease in the overall amount of analgesia administered was noted. An explanation for the decreased analgesia administration was that the providers in the study were able to use this tool to discriminate pain from other symptoms (eg, anxiety, delirium). This study was not designed to show differences in patient outcomes.

The first step in the Analgesia-Delirium-Sedation (ADS) Protocol was to assess injured patients' level of pain before administration of sedatives. Following titration of pain medications to a predetermined goal, delirium and anxiety were then assessed and treated. Nursing staff were trained and assessments were repeated on a 4-hour schedule. Patients in the protocol group had decreased ventilator days as well as an overall shorter hospitalization.³⁴ Other studies have shown similar results.³⁵ In a randomized study performed by Brook and colleagues,³⁶ a protocol involving fentanyl for pain and lorazepam for anxiety resulted in decreased hospital and ICU length of stay over a nonprotocolized regimen. Although no one protocol is better than another, there appears to be no harm in its introduction. Sessler and Pedram³⁷ summarized these protocols with the following simple questions: Is the patient comfortable? Is the patient in pain? Is the patient anxious? Different assessment strategies may be used to answer these questions. Directing treatment toward the answers is the foundation of analgesia-sedation treatment protocols.

INTRAVENOUS AGENTS

Traditional Opioids

Intravenous opioids have been the mainstay of pain medications in the ICU for years. Recently, more data have become available on agents such as remifentanyl and ketamine. Most patients are currently maintained on a regimen built on a foundation of traditional opioids.^{38,39} The sedating side effect of these medications has been used to assist with compliance with mechanical ventilation. NSAIDs, such as ketorolac, although used frequently in the general surgical population, will not be discussed, as there are few data in the ICU population and use should be limited given the side-effect profile.

Much of the pharmacokinetic data for opioids come from single-dose studies from healthy volunteers.⁴⁰ Caution is required in the critically ill population receiving continuous infusions, as these patients have altered volume status, protein-binding capability, and end-organ (renal and hepatic) function. Morphine, fentanyl, and

hydromorphone are the most commonly used opioids in the ICU setting.⁴¹ They exhibit stimulation of the μ -opioid, κ -opioid, and δ -opioid receptors with the primary site being the μ -receptor.⁴² Opioids are divided into 3 classes and are broken down by chemical structure: (1) morphine-like agents (morphine and hydromorphone); (2) meperidine-like agents (meperidine, fentanyl, and remifentanyl); and (3) diphenylheptanes, which include methadone.⁴²

The intravenous route is preferred in the ICU,⁴⁰ as this affords a faster onset, higher bioavailability, and better dose titration. Of the 3, fentanyl has the fastest onset because of its high lipophilicity. It should be noted that this characteristic allows fentanyl to accumulate in patients after frequent dosing or continuous infusion.⁴³ Opioids are metabolized in the liver and excreted renally. Morphine undergoes glucuronidation to active metabolites that can accumulate in patients with decreased renal function. Although fentanyl does not have an active metabolite, the parent compound may accumulate in patients with renal insufficiency, and should be dosed cautiously.⁴⁴ Hydromorphone-3-glucuronide (the metabolite of hydromorphone) is inactive and therefore hydromorphone should be considered the drug of choice in patients exhibiting decreased renal function.¹⁹

Tolerance, the decrease in a drug's efficacy over time despite constant plasma concentrations, is exhibited with all opioids.⁴⁵ Synthetic opioids, such as fentanyl, may exhibit tolerance earlier than their nonsynthetic counterparts. This is likely because of the higher receptor affinity.⁴⁶ Tolerance may develop in as quickly as one week of continuous or high-dose infusion. Rapid discontinuation or de-escalation may lead to withdrawal symptoms and may be confused for other sources of delirium. Methadone reduces the occurrence of these effects.⁴⁷

Remifentanyl

The side-effect profile of morphine (pruritis, histamine release, and accumulation of active metabolites) may at times prohibit its use.⁴⁸ Although the synthetic agents (fentanyl, alfentanil, and sufentanil) have better adverse-effect profiles, they can still accumulate in critically ill patients, leading to prolonged drug effects.¹⁹ Remifentanyl has been evaluated as a superior alternative. Chemically, it is in the same class as fentanyl; however, its clearance is quite different. Remifentanyl is broken down by nonspecific esterases and its metabolism is unaffected by critical illness.⁴⁹ The metabolite, remifentanyl acid, is an inactive carboxylic acid with a low affinity for the μ -receptor.⁵⁰ The efficacy of remifentanyl for prolonged mechanical ventilation was evaluated by Evans and Park.⁵¹ They maintained patients from 3 to 33 days on doses ranging from 0.08 $\mu\text{g}/\text{kg}$ to 0.43 $\mu\text{g}/\text{kg}$ with all patients showing signs of recovery within 10 minutes of discontinuing the medication. In a blinded, randomized trial evaluating remifentanyl versus morphine for mechanically ventilated patients, Dahaba and colleagues⁵² noted a decreased need for dose adjustment, increased time spent in optimal sedation, and decreased ventilator hours (14.1 vs 18.1). A similar study in cardiac patients noted similar results with significantly shorter interval from ICU admission to extubation as well as time to ICU discharge.⁵³ This study also evaluated cost, noting no difference between the 2 groups.⁵⁴

Remifentanyl was evaluated in neurologic patients in the ICU, including patients suffering traumatic brain injury. There was no difference in time to extubation between remifentanyl and fentanyl, but neurologic function assessment was improved in the remifentanyl.⁵⁵ A retrospective study by Bauer and colleagues⁵⁶ evaluating remifentanyl in patients undergoing supratentorial brain tumor surgery noted decreased ventilator days in the remifentanyl group (1.8 vs 3.7 days). Interestingly, 3 patients in the fentanyl group required computed tomography scans of the head, as they did not

awaken for neurologic assessments; a situation not encountered in the remifentanyl group.

Ketamine

Ketamine is a phencyclidine derivative causing disorganization between thalamocortical and limbic systems leading to a dissociative state. The anesthetic properties of ketamine work primarily through the central nervous system (CNS) on the N-methyl-D-aspartate receptors, whereas the analgesia effects are obtained with stimulation of the μ -opioid and κ -opioid receptors.⁵⁷ Ketamine, at subanesthetic infusion rates, delivers effective analgesia while exhibiting qualities favorable in the critically ill patient. Unlike high-dose opioid infusions, patients on a ketamine infusion will maintain pharyngeal and laryngeal reflexes while preserving respiratory effort.⁵⁸ Ketamine reduces airway resistance and can treat severe bronchospasm refractory to traditional bronchodilators. Increases in PaO₂ associated with decreases in PaCO₂ are noted in ventilated patients with severe bronchospasm when given ketamine.⁵⁹ Studies evaluating dynamic compliance (as a surrogate for bronchospasm) have noted relative increases in patients undergoing ketamine infusions.⁶⁰

Ketamine, in addition to its favorable effects on respiratory physiology, has hemodynamic effects desired in a critically ill patient.⁶¹ Studies show no significant changes in systolic, diastolic, or mean arterial pressures when given in standard doses.⁶² There is no significant change in peripheral vascular resistance, a favorable property in many critically ill states. Vasopressor requirements in patients on ketamine are unchanged or decreased as compared with patients on fentanyl infusions.⁶³ This finding, along with the need for decreased volume resuscitation, was also noted in traumatic brain injury.⁶⁴

Caution should be exhibited in patients with decompensated heart failure or cardiogenic shock.⁶⁵ Patients with pulmonary hypertension should likely not receive ketamine, as there may be some elevation of pulmonary pressures.⁶⁶ Despite the positive effects seen in traumatic brain injury (as well as literature supporting the absence intracranial pressure elevation with infusion) ketamine is both a proconvulsant and anti-convulsant and should be avoided in patients with seizure disorders.

REGIONAL ANALGESIA

Overview

For most patients in the ICU, pain management with systemic opioids is both effective and appropriate. There are times, however, when this method is less than ideal, either because of excessive/uncontrolled side effects or simple inability to adequately obtain pain control. For some of these patients, pain management through a more targeted technique can be ideal. Consider an elderly patient with multiple rib fractures unable to breathe well secondary to pain, but too sedate or obtunded from opioids. Placement of a continuous epidural or paravertebral block may enable this patient to maintain spontaneous ventilation and allow the patient to participate in respiratory and physical therapy.

Effective use of regional analgesia in the ICU has its share of barriers. Practitioners must be skilled in the placement of varied blocks. They must be knowledgeable of the various techniques to know what is possible. Practitioners must be aware of complications unique to the placement of these blocks and catheters. Nursing must be comfortable with the management of the devices used for continuous infusion. It is unlikely that all of these requirements are met in many hospitals, which limits the utility of many of these anesthetic techniques. Further, at present there is a relative dearth of

evidence supporting the use of many available techniques in the ICU as a means of improving outcomes.

Indications and Contraindications

Analgesic management with regional techniques should be considered whenever the risk of system use of narcotics is high or when the pain itself is reasonably well localized to one or more anatomic areas. Large surgical incisions, such as a thoracotomy or laparotomy, upper and lower extremity orthopedic procedures, and rib fractures from trauma, are examples of this type of pain. These sources of pain can frequently be managed by the placement of a continuous epidural (thoracic or lumbar) or extremity block, such as a femoral or sciatic nerve. Further, the use of regional techniques for short-term control of pain for procedural benefits can be of great benefit, especially in a morbidly obese patient with obstructive sleep apnea and hypersensitivity to the respiratory depression associated with opioids. Benefits associated with regional analgesia are somewhat contradictory and do not always seem to show improvements in outcome variables.^{67–70} There is good evidence that, at least in the case of neuraxial techniques, use of regional analgesia can both shorten the duration of mechanical ventilation and reduce the incidence of pneumonia.⁷¹ Additionally and potentially more compelling, there is a growing body of evidence linking the use of narcotics and sedatives to the development of delirium and cognitive dysfunction,^{38,72,73} which might be reduced or avoided altogether by the successful use of these techniques.

Not all patients in the ICU can be considered candidates for regional pain management; even should they meet the considerations noted previously. For example, the patient with multiple trauma, for whom adequate positioning cannot be performed, patients with severe scoliosis or other anatomic deformities, patients in whom the location of the block is obscured by either infection or their underlying injuries, and those with coagulopathies all may be ineligible for placement of a regional block. With regard to patients receiving anticoagulation therapy or otherwise at increased risk of bleeding, there are consensus guidelines available from the American Society of Regional Anesthesia delineating risk factors, complications, and recommendations, which are regularly updated.⁷⁴

Continuous techniques require the presence of an indwelling catheter through which local anesthetic is infused. Infection related to placement of the catheter or to the patient's underlying illness (eg, sepsis) is a consideration before undertaking a regional technique. Overall, there are a variety of factors to be considered before using a regional technique in the ICU.

Epidural, Intrathecal, and Paravertebral Analgesia

Thoracic, vascular, and orthopedic procedures have long benefited from postoperative pain control with epidural analgesia. Data suggest that thoracic epidural analgesia with bupivacaine and morphine can provide superior analgesia with fewer opioid-related side effects than intravenous narcotic therapy, at least in some populations.⁶⁷ Further, epidural analgesia can improve some measures of postoperative outcomes in high-risk patients, including a reduced incidence of thromboembolism and myocardial infarction, as well as improvements in bowel and pulmonary function.⁷⁵ Additionally, a Cochrane review comparing epidural to systemic opioid techniques in elective abdominal surgery concluded that the use of a regional technique reduced time on ventilator, cardiovascular and gastrointestinal complications, and the incidence of acute renal failure, in addition to providing superior pain control.⁶⁸ Finally, a study using the National Trauma Data Bank (NTDB) noted increasing numbers of rib fractures correlated with increasing extrapulmonary complications. Patients sustaining more than 6

fractures were at a significantly increased risk of mortality compared with those injuring fewer. Epidural analgesia lowered morbidity and mortality and was especially helpful in patients with more than 4 fractures; however, most studies have failed to demonstrate that other outcome variables (eg, length of ICU or hospital stay, mortality) are affected.

Intrathecal techniques, both single dose and continuous, have the most data supporting their use for operative (and immediate postoperative) pain control. Nonsurgical patients in the ICU are rarely treated with these techniques secondary to their increased complication risk.⁷⁶ Further, the risk of undesirable side effects from intrathecal administration of opioid is much higher than that seen with epidural administration secondary to cerebrospinal fluid concentrations reaching an order of magnitude higher than that seen with epidural administration. Some of these side effects include respiratory depression, somnolence, and pruritis.

Paravertebral blockade is in many respects very similar to traditional epidural techniques. The primary advantages to a paravertebral block are its one-sided nature and its limited spread to only 1 or 2 dermatomes from the site of needle placement. A catheter can be placed to enhance the degree of spread somewhat and to provide continuous analgesia. It is also possible to place multiple catheters to enable wide coverage of the thoracic cage unilaterally. A unique risk associated with the placement of a paravertebral block, as opposed to an epidural or intrathecal technique, is the development of a pneumothorax. A comparison of block techniques, and their indications and associated risks, can be found in **Table 2**.⁷⁵

Type of Block	Block Indication	Special Considerations
Thoracic epidural	Thoracic surgery, chronic pancreatitis, upper abdominal surgery, rib fractures	Epidural hematoma or abscess, hypotension from sympathetic blockade, accidental intrathecal puncture/administration.
Lumbar epidural	Trauma, lower extremity surgery	Same as thoracic epidural.
Paravertebral block	Unilateral thoracic surgery, trauma, or pain	Pneumothorax.
Intercostal block	Chest tube placement, rib fracture	Pneumothorax, high potential for intravascular injection, highest systemic concentrations of local anesthetic even without intravascular injection.
Femoral or sciatic block	Thigh, knee, leg pain	Positioning challenges with sciatic block. Fewer hemodynamic derangements than neuraxial techniques.
Interscalene, supraclavicular, infraclavicular, or axillary block	Arm, shoulder, or hand pain, trauma, or surgery	Technique dependent. Variable spread. Intravascular or intrathecal injection, phrenic nerve block (100% with interscalene).

Adapted from Fishman SM, Ballantyne JC, Rathmell JP, editors. *Bonica's management of pain*. 4th edition. Philadelphia: Lippincott, Williams and Wilkins; 2010. p. 1589; with permission; and *Data from* Fishman SM, Ballantyne JC, Rathmell JP, editors. *Bonica's management of pain*. 4th edition. Philadelphia: Lippincott, Williams and Wilkins; 2010. p. 1596.

Intercostal Nerve and Interpleural Blocks

For patients with limited chest trauma, or patients experiencing pain secondary to chest tubes, epidural analgesia is frequently either simply not considered or considered unnecessary by some. However, the pain associated with even singular rib fracture can cause pulmonary complications secondary to decreased respiratory effort and the frequent need for large doses of opioids to ameliorate the pain associated with movement. For these patients, especially if epidural analgesia is contraindicated, it is prudent to consider intercostal nerve blocks. Data on the utility of intercostal blocks in the ICU are limited. One study comparing the effectiveness of intercostal blockade with that of an epidural found the epidural to be superior in providing analgesia; however, improvements in other parameters, such as respiratory performance and ICU length of stay, only trended to be in favor of the epidural.⁷⁷ Disadvantages to the intercostal technique include the need for multiple injections, even at single levels of injury, as adequate pain control typically requires anesthesia covering the injured rib as well as one level above and below. Additionally, duration of analgesia is typically in the range of 4 to 8 hours maximally and continuous techniques cannot be recommended secondary to complication rates. Further, serum levels of local anesthetic are highest after intercostal blockade, as compared with any other form of peripheral or neuraxial nerve block, thereby increasing the risk of local anesthetic toxicity when considering more than just 1 or 2 ribs.

Related to the intercostal nerve block is the interpleural block. This type of block is not recommended for several reasons, including the loss of local anesthetic via chest drains, dilution of local anesthetic in the pleural space by blood or pus, and the highly variable nature of the nerve blockade secondary to substantial changes in local anesthetic concentrations from positional effects.

Peripheral Nerve Blocks

There are few data available specifically on the use of peripheral nerve blockade in the ICU setting. Exclusively, all randomized controlled trials involving peripheral nerve blockade are in the perioperative setting and include patients both in and out of the ICU without outcomes comparisons. As with other regional techniques, however, the use of systemic opioids and the complications associated with those medications is reduced when peripheral blockade is available and the patient's anatomic pain is amenable to this type of intervention.

CONSIDERATIONS IN THE GERIATRIC POPULATION

The geriatric population (patient age >65) deserves special consideration, as treatment of surgical and traumatic pain differs from that of their younger counterparts. This population exhibits differences in sensitivity to painful stimuli, has increased sensitivity of the CNS, and suffers from pharmacodynamic and pharmacokinetic changes affecting medication doses and side effects.⁷⁸ As the excess catecholamine release from pain in the elderly can have cardiac side effects, undertreatment may be as dangerous as the side effects from overtreatment.⁷⁹

Pain Threshold

Research suggests that as age increases, pain threshold increases as well. There appears, however, to be a concomitant decrease in pain tolerance.⁸⁰ Given these opposed changes, elderly patients experience postoperative pain in the same fashion as younger patients. Although the elderly may have a lack of the sense of pain with

arteriolar occlusion, myocardial ischemia, and bowel distension, there is no evidence that advanced age dulls the "sense" of pain.^{81,82}

Delirium and CNS Effects

Delirium, as discussed elsewhere in this issue, is recognized as a significant cause of morbidity and mortality in critically ill patients. Elderly patients are more subject to CNS disturbances especially during times of severe physiologic stress.⁸³ Pain itself can lead to delirium, thereby complicating assessment of pain.⁸⁴ This cycle is exacerbated in patients with preexisting dementia or delirium.⁷⁸ It is well recognized that most traditional pain medications can lead to delirium as well. Finding a balance between adequate pain control while limiting CNS impairment can be a challenge, but doing so should not interfere with treating the patient's pain.

Alterations in Drug Metabolism

Pharmacodynamics change very little with increasing age.^{85,86} The dose required to achieve the same end-point may be decreased and the therapeutic window may be narrowed. Conversely, pharmacokinetics can be greatly affected by advanced age.⁸⁷ Increasing age yields decreased lean body mass, decreased total body water, and an increased proportion of body fat. These changes combine to alter the volume of distribution of medications, affecting clearance and elimination.⁸⁸ Elderly patients will exhibit decreased renal and hepatic drug clearance. The renal blood flow decreases approximately 10% per decade of life after the age of 50. Liver mass decreases with age, as does hepatic blood flow.⁸⁹ The combined affect is to decrease drug metabolism.⁹⁰ Decreased circulating albumin interferes with drug binding, as well.⁹¹ Also, cardiac, pulmonary, and neurologic depression seen in aging make hypotension, hypoxia, hypercarbia, acidosis, and altered fluid regulation more common. This depressed basal organ function may not be present at rest, only presenting itself during times of physiologic stress.⁸⁸

Rib Fractures in the Elderly

Elderly trauma patients with rib fractures exhibit an observed mortality higher than expected for a given injury severity scale. It is likely a combination of the underlying lung injury, as well as other extrathoracic injuries. In one study, this patient population had twice the mortality of similarly injured younger patients. Each injured rib increased mortality by nearly 20% with a concomitant 30% increase in the risk of pneumonia.⁹² Adequate pain control is necessary to avoid delayed pulmonary complications. Respiratory depression associated with narcotic analgesia, however, may instead contribute to such complications. Regional and local analgesia in this population has very favorable data.

A retrospective study by Bulger and colleagues analyzed elderly patients receiving epidural analgesia compared with those receiving traditional pain medications.⁹² In that study, the epidural group was more severely injured and had higher rates of pulmonary complications, total length of stay, and length of ICU stay. Despite the higher chest abbreviated injury score and increased complication rates, this group had a significantly lower mortality (11% vs 25%).⁹³ In the absence of contraindications, regional analgesia should be offered to elderly patients with 4 or more rib fractures, or those with respiratory compromise secondary to injured ribs.⁹⁴

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