Regional Anesthesia in Trauma Patients

Cesare Gregoretti, MD a,*, Daniela Decaroli, MD a, Antonio Miletto, MD a, Alice Mistretta, MD b, Rosario Cusimano, MD a, V. Marco Ranieri, MD b

a Dipartimento Emergenza Accettazione, ASO CTO-CRF-Maria Adelaide, Via Zuretti 29, 10129 Torino, Italy
b Università di Torino, Dipartimento di Anestesiologia e Rianimazione, Ospedale S. Giovanni Battista-Molinette Torino, Corso Bramante 89, 10129 Torino, Italy

Trauma is a major cause of mortality throughout the world and pain is the most common symptom reported by patients admitted to the emergency room [1]. Specific protocols have been developed to treat all pain-related complications, such as posttraumatic stress disorders [2], making anesthesiologists more involved in the management of trauma patients. Even though data demonstrating that regional anesthesia improves outcome are lacking, improved pain management in the trauma patient not only increases comfort and reduces patient suffering but has also been demonstrated to reduce the rate of intubation and morbidity and to improve short- and long-term outcomes [3–6].

Shulz-Stubmer and colleagues [7] reported that regional analgesia using single-injection regional blocks and continuous neuraxial and peripheral catheters can play a valuable role in a multimodal approach to pain management in trauma patients admitted in the intensive care unit.

Although surgical interventions for multiple trauma more frequently require general anesthesia (GA), regional anesthesia (RA) should be considered in patients who have isolated orthopedic injuries [8,9] and in burn patients [7]. A meta-analysis [10] showed that neuraxial blocks significantly reduce postoperative mortality and morbidity (eg, deep vein thrombosis, pulmonary embolism) when compared with general anesthesia, although results for hip fracture repair are still debatable [11].

In this article we (1) describe the use of different techniques of regional anesthesia that could be potentially used in patients who have trauma,
and (2) describe indications, limitations, and practical aspects of regional anesthesia in the trauma patients [7,12–16].

**Regional anesthesia techniques for patients who have trauma**

*Subarachnoid and epidural blockade*

Subarachnoid (SAB) and epidural blockade (EB) are by far the regional anesthesia and analgesia techniques most often used in lower limb surgery; recent reports suggest the use of these techniques also to control pain in critically ill patients [6,17–22]. SAB is achieved by the introduction of drugs into the subdural space, whereas EB is achieved by the introduction of drugs into the epidural space. Medications injected epidurally act directly on spinal nerves and receptors in the spinal cord by way of diffusion across the dura and into the cerebrospinal fluid. If minimal sedation is given and a level of anesthesia below the intercostals is maintained, mental status and respiratory function can be well maintained [8].

The more common patient population potentially available for such procedures includes elderly patients who have multiple comorbidities [23] and significant perioperative morbidity and mortality [11,22]. Scheini and colleagues [24] found that a perioperative continuous epidural bupivacaine/fentanyl analgesic regimen reduced the number of myocardial ischemic events in elderly patients who had hip fracture. Recent data suggest that the incidence of severe adverse cardiac events was significantly lower with preoperative epidural analgesia than with standard intramuscular analgesia in patients who had hip fractures [20]. Review of the literature, however, indicates that neither technique offers a significantly better outcome than the other [12], although Urwin and colleagues [13] reported less 1-month mortality in patients receiving regional anesthesia. During replantation and revascularization surgery to date EB does not seem to favor increased blood flow [25].

Cardiovascular instability related to sympathetic block is the most common side effect. Bradycardia and hypotension can be more pronounced with intermittent-bolus dosing in patients who have reduced preload as hypovolemic geriatric patients [8]. These patients often have a pre-existing fluid deficit that is compounded by blood loss from fracture sites into muscular compartments [8]. To avoid hypotension associated with the onset of sympathectomy careful fluid management, with or without the use of invasive monitoring, should be maintained throughout the perioperative period.

A major limitation of epidural analgesia is that it is segmental, needing large volumes of local anesthetics (LAN) to cover extensive injuries (see section dedicated to medications) and the patient’s coagulation status.

Recommendations of the American Society of Regional Anesthesia [26] should be followed when considering a patient’s coagulation and administration of anticoagulative drugs [27]. Catheter removal must follow the same placement indications. A more extensive review of regional anesthesia
Peripheral nerve blocks

Introduction of new methods and techniques is increasing and improving the use of lower peripheral nerve blocks (PNBs) on the trauma scene. These techniques are also gaining interest after the important increase of the low molecular weight heparins [5,8]. PNBs offer these advantages in the trauma setting: (1) avoid side effects of GA, (2) avoid side effects of neuraxial block, (3) allow rapid and effective analgesia without side effects of systemic analgesics, (4) allow sympathectomy when performed for upper limb surgery with the related advantages in graft surgery [25].

Lower extremities

In patients who have unilateral lower limb fractures who are not candidates for EB regional anesthesia of nerves coming from the lumbar plexus and the sciatic nerve can provide excellent pain relief and good anesthesia at the surgical level. Femoral nerve block or catheters placed with or without the use of an electrical nerve stimulator (ENS) are helpful in the management of acute pain from femoral neck fractures in the perioperative period [32–36] and in prehospital care [37].

Fletcher and colleagues [35] showed that femoral block provides quicker relief than systemic intravenous morphine (5–10 mg/h). The benefit of femoral block was also shown by Lopez and colleagues [37] to facilitate the sitting position for spinal anesthesia.

There are several different techniques that can be used to block the sciatic nerve. Anterior or posterior approach—midgluteal, subgluteal, classic Labat approach—with one or two injections, depends largely on the skills of the operator and the ability to position the patient for the procedure [36–42]. In foot or ankle surgery a popliteal approach might be performed [43].

Table 2 [44] shows indications, contraindications, and practical problems of different types of continuous peripheral nerve blocks in the lower extremities [45–52].

Upper extremities

Upper-limb blocks by way of the brachial plexus are used for laceration repairs, closed reductions, or surgery performed on the arm nerves as a means to prevent neurogenically mediated vasospasm in re plantation [25]. Continuous plexus and peripheral nerve blocks offer the potential benefits of prolonged analgesia provided a catheter is positioned [53–62], with fewer side effects, greater patient satisfaction, and faster functional recovery after surgery.
<table>
<thead>
<tr>
<th>Type of block</th>
<th>Indications</th>
<th>Contraindications</th>
<th>Advised doses</th>
<th>Practical problems and suggestions in trauma patient</th>
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</thead>
<tbody>
<tr>
<td>Subarachnoid</td>
<td>Orthopedic surgery or trauma of lower extremities</td>
<td>Patient refusal Coagulopathy or current use of anticoagulants, low platelet count [27,28], sepsis/bacteremia [29] Critical aortic stenosis [8] Local infection overlying the needle insertion Severe hypovolemia or acute hemodynamic instability Obstructive ileus Elevated intracranial pressure Pre-existing neuropathy or vertebral trauma Local anesthetic allergies</td>
<td>Surgery: 1.6–2 mL of 0.5 hyperbaric bupivacaine injected over 30 s on L3-L4 and maintaining lateral position for 15 min [30,31] Intrathecal morphine [98,99] injections as single shot or by spinal catheters</td>
<td>Difficult patient positioning, multiple fractures, number and position of tubes and catheters, or external fixation bone devices: another technique should be evaluated Abnormal anatomy: another technique should be evaluated Inability of the patient to cooperate: another technique should be evaluated Hypotension: before the initiation of subarachnoid blockade patients should be carefully hydrated [8]</td>
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<tr>
<td>Condition</td>
<td>Surgery:</td>
<td>Postoperative analgesia:</td>
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<td>Epidual Orthopedic surgery or trauma of lower extremities</td>
<td>10–15 mL of 0.75% ropivacaine ± 10 μg of sufentanil or 10–15 mL of 0.5% bupivacaine ± 10 μg of sufentanil on L4-L5 [98]</td>
<td>Bolus regimen: 5–10 mL of 0.125%–0.25% bupivacaine or 0.1%–0.2% ropivacaine every 8–12 h</td>
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<td>Patient refusal</td>
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<td>Consider addition of 1 μg/kg of clonidine in hemodynamically stable patients</td>
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<tr>
<td>Coagulopathy or current use of anticoagulants, low platelet count [26–28]</td>
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<td>Continuous infusion: 0.0625% bupivacaine or 0.1% ropivacaine at 5 mL/h</td>
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<td>Local infection overlying the needle insertion and sepsis/bacteremia [29]</td>
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<td>Consider addition of opioids (eg, hydromorphone, sufentanil) or clonidine if high systemic opioid demands persist</td>
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<td>Severe hypovolemia or acute hemodynamic instability</td>
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<td>Obstructive ileus</td>
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<td>Elevated intracranial pressure</td>
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<td>Pre-existing neuropathy or vertebral trauma</td>
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<td>Local anesthetic allergies</td>
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<td>Difficult patient positioning and catheter tunneling: another technique should be evaluated</td>
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<td>Abnormal anatomy: another technique should be evaluated</td>
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<td>Inability of the patient to cooperate: another technique should be evaluated</td>
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Table 2
Different types of continuous peripheral nerve blocks in the lower extremities

<table>
<thead>
<tr>
<th>Type of block</th>
<th>Indications</th>
<th>Contraindications</th>
<th>Advised doses&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Practical problem and suggestions in trauma patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral or sciatic nerve</td>
<td>Unilateral leg surgery when both fields of innervation are blocked.</td>
<td>Patient refusal, Local infection overlying the needle insertion, Pre-existing neuropathy, Local anesthetic allergies</td>
<td>Surgery: 10–15 mL of 0.75% ropivacaine or 10–15 mL of 0.5% bupivacaine or 10–15 mL of 2% mepivacaine for femoral nerve block, 15 mL of 0.75% ropivacaine or 15 mL of 0.5% bupivacaine or 15 mL of 2% mepivacaine for sciatic nerve block&lt;sup&gt;[44]&lt;/sup&gt;, Consider addition of 1 μg/kg of clonidine in hemodynamically stable patients&lt;sup&gt;[45,47]&lt;/sup&gt;, Postoperative analgesia: Bolus regimen: 10 mL of 0.25% bupivacaine or 0.2% ropivacaine every 8–12 h and on demand, Continuous infusion: 0.125% bupivacaine or 0.1%–0.2% ropivacaine at 5 mL/h&lt;sup&gt;[6,59]&lt;/sup&gt;</td>
<td>Difficult patient positioning: all possible technical approaches should be evaluated, Obese patient: all possible technical approaches should be evaluated, Interference of femoral nerve catheters with femoral catheters (central venous catheter, arterial catheters) wounds or other alterations of site of puncture: another technique should be evaluated, Pain because of ENS: skilled use of ultrasound&lt;sup&gt;[50]&lt;/sup&gt;, fascia iliaca compartment block, or small doses of intravenous remifentanil (0.3–0.5 g/kg) or ketamine (0.2–0.4 mg/kg)&lt;sup&gt;[11]&lt;/sup&gt; might limit the unavoidable&lt;sup&gt;[6]&lt;/sup&gt;, Target sedation score Ramsey = 2&lt;sup&gt;[51]&lt;/sup&gt;</td>
</tr>
<tr>
<td>Posterior tibial and popliteal sciatic nerve</td>
<td>Unilateral foot surgery</td>
<td>Patient refusal, Local infection overlying the needle insertion, Pre-existing neuropathy, Local anesthetic allergies</td>
<td>Surgery: 15–20 mL of 0.75% ropivacaine or 15–20 mL of 0.5% bupivacaine or 15–20 mL of 2% mepivacaine&lt;sup&gt;[52]&lt;/sup&gt;</td>
<td>Patient positioning: another technical approach should be evaluated</td>
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</table>

<sup>a</sup> Maximal dose for single administration: mepivacaine 7 mg/Kg (max 1000 mg/24 h), bupivacaine 2 mg/kg (max 150 mg for single administration), levobupivacaine 150 mg (max 400 mg/24 h), ropivacaine 300 mg (max 675 mg/h).
In upper extremity surgery either interscalene, axillary, or supraclavicular/infracavicular and cervical paravertebral approaches to the brachial plexus block can be used for anesthesia and also for continuous analgesia [7,53–73]. Interscalene block provides the most reliable anesthesia for shoulder pain and surgery [53–56]. For most authors a continuos block is the analgesia technique of choice, providing better pain control than patient-controlled analgesia with morphine [57,58]. The modified approach by Boezart and colleagues [53] seems to reduce the incidence of catheter dislodgement.

Although it has been demonstrated that patient-controlled analgesia with opioid produces similar effects on pulmonary function as the ipsilateral interscalene block [59], the major limitation of the interscalene block is the unavoidable blocking of the phrenic nerve and the loss of hemidiaphragmatic activity [56].

Infraclavicular and axillary blocks are able to provide good anesthesia levels for surgery of the upper extremities. The continuous infraclavicular and axillary [54,55,64–73] approaches also provide a good level of analgesia during the perioperative period and even days after surgery in patients who need surgical anesthesia for painful wound dressing changes or debride-ments for major burns [7]. For this reason a catheter positioning instead of single shot technique must be considered. The supraclavicular approach has been almost abandoned because of related high frequency of pneumothorax.

Table 3 [74,75] shows indications, contraindications, and practical problems of different types of continuous peripheral nerve blocks in the upper extremities [76,77].

**Analgesia techniques for chest pain**

The main advantages to reducing chest pain beyond leaving the patient feeling more comfortable are: (1) to improve respiratory function by decreasing pain on inspiration, allowing deep breath; (2) to allow upright or sitting position [78]; (3) to improve coughing efficacy with decreased risk for atelectasis, hypoxemia, and associated morbidity and mortality [79,80].

Based on current evidence it is difficult to recommend a single method that can be used safely and effectively for analgesia in patients who have multiple fractured ribs [81]. Epidural analgesia has been used after thoracotomy or for multiple rib fractures [80–86] and has been shown to be an independent predictor of decreased morbidity and mortality in thoracic trauma [85] along with improving outcomes in patients who have rib fractures [3].

When EP is contraindicated, intrapleural catheters [86] and thoracic paravertebral catheters [87] can be used as an alternative to epidural catheters for the management of unilateral pain, for rib fractures after chest trauma, or for chest surgery. The major limitations of these techniques is that paravertebral catheters can control pain restricted to a few dermatomes, whereas intrapleural catheters are of limited value secondary to concurrent drainage
<table>
<thead>
<tr>
<th>Type of block</th>
<th>Indications</th>
<th>Contraindications</th>
<th>Advised dosesa</th>
<th>Practical problems and suggestions in trauma patient</th>
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<tr>
<td>Interscalene</td>
<td>Shoulder/arm surgery</td>
<td>Patient refusal</td>
<td>Surgery: 20–30 mL of 0.5% ropivacaine or 20–30 mL of 0.5% levobupivacaine; 15 mL of 0.5 ropivacaine + GA or 10–15 mL of 0.125% bupivacaine + GA [76]</td>
<td>Block of ipsilateral phrenic nerve: see contraindications</td>
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<td>Untreated contralateral pneumothorax</td>
<td>Postoperative analgesia: Bolus regimen: 10 mL of 0.25% bupivacaine or 0.2% ropivacaine every 8–12 h and on demand</td>
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<td>Dependence on diaphragmatic breathing</td>
<td>Continuous infusion: 0.125% bupivacaine or 0.1%–0.2% ropivacaine at 5 mL/h [7]</td>
<td>Horner syndrome: may obscure neurologic assessment; diagnostic differential diagnosis with head trauma must be carefully evaluated</td>
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<td></td>
<td>Contralateral vocal cord palsy</td>
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<td>Close proximity to tracheostomy and jugular vein catheter sites [7]: use of the cervical paravertebral approach should be considered [61,62] to reduce the risk for infection</td>
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<td></td>
<td></td>
<td>Local infection overlying the needle insertion</td>
<td></td>
<td>Risk for accidental subdural injection [63]: combination of ultrasound and nerve stimulation should be used in sedated patients [66]</td>
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<td></td>
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<td>Patients who have reduced functional residual capacity, aged patients who have chest trauma or difficult-to-wean patients [7,22]</td>
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<td>Risk for accidental arterial/venous/nerve injury</td>
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<td>Pre-existing neuropathy</td>
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<td>Local anesthetic allergies</td>
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a. GA: General Anesthesia

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<table>
<thead>
<tr>
<th>Location</th>
<th>Surgery Details</th>
<th>Anesthesia Details</th>
<th>Additional Notes</th>
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<tbody>
<tr>
<td>Infraclavicular/ supraclavicular</td>
<td>Patient refusal, Severe coagulopathy, Untreated contralateral pneumothorax, Local infection overlying the needle insertion, Pre-existing neuropathy, Local anesthetic allergies</td>
<td>Surgery: 20–30 mL of 0.5% ropivacaine or 20–30 mL of 0.5% levobupivacaine; 15 mL of 0.5 ropivacaine + GA or 10–15 mL of 0.125% bupivacaine + GA [76]</td>
<td>Pneumothorax risk: see contraindications, Interference with subclavian central venous catheters, A lateral infraclavicular approach [60–62] might help to reduce the risk for pneumothorax, Risk for accidental arterial/venous injury and risk for arteriovenous fistula: use of ultrasound should be evaluated</td>
</tr>
<tr>
<td>Axillary</td>
<td>Patient refusal, Local infection overlying the needle insertion, Pre-existing neuropathy, Local anesthetic allergies</td>
<td>Surgery: 20–40 mL of 0.5% ropivacaine or 20–40 mL of 0.5% bupivacaine [73]</td>
<td>Arm positioning, Not suitable for catheter positioning</td>
</tr>
<tr>
<td>Cervical paravertebral</td>
<td>Patient refusal, Local infection overlying the needle insertion, Pre-existing neuropathy, Local anesthetic allergies</td>
<td>Surgery: 30 mL of 0.25% bupivacaine</td>
<td>Risk for accidental arterial/venous injury, Risk for accidental subarachnoid l injection</td>
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<tr>
<th>Type of block</th>
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<tr>
<td>Stellate ganglion block</td>
<td>Arm/hand vascular surgery</td>
<td>Patient refusal</td>
<td>Selective sympathetic nervous system block: 8–10 mL of 1% lidocaine or 0.25% bupivacaine [75]</td>
<td>Risk for accidental vertebral arterial injection&lt;br&gt;Risk for accidental subarachnoid injection&lt;br&gt;Pneumothorax&lt;br&gt;Hoarseness from recurrent laryngeal nerve paralysis</td>
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<td>Untreated contralateral pneumothorax</td>
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<td>Local anesthetic allergies</td>
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<td>Median nerve block block</td>
<td>Hand surgery</td>
<td>Patient refusal</td>
<td>Surgery 5–10 mL 0.5% ropivacaine or 5–10 mL of 0.5% bupivacaine [73]</td>
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<td>Local infection overlying the needle insertion</td>
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from chest tubes [7]. Intercostal nerve block is an effective form of analgesia, and for most patients who have rib fractures one intercostal nerve block is sufficient to allow adequate respiratory exercise and discharge from the hospital [88]. The incidence of pneumothorax per individual intercostal nerve blocked is low.

Other analgesia techniques

Continuous lumbar plexus block may provide relief for acute postoperative pain management after open reduction and internal fixation of acetabular fracture [89]. Celiac plexus blocks may provide excellent analgesia for pancreatitis secondary to trauma but technical difficulties (computed tomography guidance, fluoroscopy, or transgastric ultrasound) and the need for repeated injections limit its use [7]. Single-shot nerve blocks, such as scalp block for the placement of halo fixation, vascular approaches are often forgotten although easy and safe to perform [7,90]. Topical anesthesia can be achieved with Lidocaine-Prilocaine cream (EMLA, AstraZeneca, London). It needs to be applied 30–45 mins before the procedure to achieve an optimal effect [7].

Practical aspects of regional anesthesia in patients who have trauma

Medications

The most frequently used medications for regional analgesia or anesthesia are LAN injected neuraxially or during peripheral nerve blocks, which arrest nerve conduction by way of the blockade of sodium channels. As a consequence, they block the transmission of nerve fibers, not just the A-delta and C fibers responsible for pain. LAN have been shown to have dose-dependent negative effects, such as neurotoxicity, cardiotoxicity, and central nervous excitation or depression, and other side effects not related to dosage quantity, such as myotoxicity and inhibition of wound healing [90,91].

Because of traumatic disease plasma levels on anesthetic can change in critically ill patients [92]. Ropivacaine has been demonstrated to have lower toxicity when compared with bupivacaine and it is indicated for scheduled or long surgery [93–95].

The other most commonly used drugs for epidural analgesia are opioids [96,97]. They act through mu, kappa, and delta receptors in the substantia gelatinosa of the spinal cord. One advantage of epidural opioids over the local anesthetics is the lack of autonomic and motor blockade. In addition, because a major limitation of epidural analgesia is that it is segmental and requires large volumes of LAN, hydrophilic drugs, such as morphine, exhibit greater segmental spread and result in better pain relief than lipid-soluble drugs [98,99]. Because of the 10-fold reduction in equianalgesic doses of opioids between the epidural and intravenous routes, prevalence of certain side effects, such as sedation and constipation, during neuraxial
administration is reduced [6]. Unfortunately, greater rostral spread also results in a higher prevalence of side effects [33] and pruritus is more common with the neuraxial route [97]. Complications attributable to high systemic doses of opioids also include sleep disorders, delirium, mental status changes, gastrointestinal dysfunction, and withdrawal syndrome. During PNBs addition of 50 to 150 μg of clonidine in a hemodynamically stable patient or 150 to 300 μg of buprenorphine [45,100] to prolong duration of action may be considered, although there is still controversy in peripheral blocks [46,47]. Clonidine has also been used in neuraxial blocks [48].

A prospective study demonstrated that pain assessment increased the likelihood of analgesic administration to trauma patients [101]. Pain severity scores seem to be underused, however [102]. During the perioperative period preemptive analgesia to reduce the magnitude and duration of postoperative pain shows evidence for a central component of postinjury pain hypersensitivity not only in experimental studies but also in clinical trials [103].

Catheter placement and maintenance

The safety of placing epidural catheters in critically ill patients is related to the level of the patient’s consciousness, systemic inflammatory response status, hemodynamic stability, and coagulation, and the use of any anticoagulant medications or antiplatelet drugs [15–17,23,26–28,104]. Regarding the patient’s coagulation status, catheter removal must follow the same placement indications [27,28]. Diagnostic approaches, including computed tomography imaging and magnetic resonance, should be considered in the presence of clinical or warning signs of possible bleeding complications.

To prevent local anesthetic side effects from accidental intravascular injection aspiration is strongly suggested during catheter placement to check for blood return and a test dose of local anesthetic or saline with 1:200,000 epinephrine. Because of the traumatic underlying disease and related use of cardiovascular drugs (ie, β blockers, α-2 agonists, catecholamines), cardiovascular parameters, such as heart rate, blood pressure, and ECG changes [94], might be altered. Premedication and deep sedation can also mask side effects [105].

The correct position of the epidural catheter can be achieved by electrical stimulation during placement or a postplacement radiograph with a small amount of non-neurotoxic contrast [106,107].

The routine neurologic daily assessment for long-term catheter can be performed by bolus injections of long-acting local anesthetics, such as bupivacaine, ropivacaine, or levobupivacaine, or the discontinuation of continuous infusions [5,7].

Use of subarachnoid microcatheters, currently not approved in the United States but approved in Europe, can be an alternative to epidural catheters, especially if only short-term use after surgery is anticipated [7].
Catheters suitable for use with ENS should never be cut because of the danger of unwinding the internal metal spiral wire that conducts current. No study has looked at the risk for reconnecting these catheters after thorough disinfection of the outer surface [7]. Regarding incidence of colonization, Cuvillon and colleagues [108] reported a high overall incidence (57%) of femoral catheters without septic complications. The authors concluded that the decision to reconnect or remove the catheter must be based on the individual clinical situation [7]. Catheters should not be removed routinely after a certain span of time but only when clinical signs of infection appear [7,109].

Structured observations of catheters for infectious complications and careful adherence to aseptic technique during placement and tunneling of the catheters, along with the possible use of antibiotic-coated catheters in the future, may reduce possible infectious complications [7].

There is no algorithm for the management of postoperative nerve injury. Most often, symptoms are first noted and referred to as an anesthetic complication by anesthesiologists. Most frequently, residual dysesthesia or hypesthesia is reported.

Summary

Although no distinct advantage is apparent between regional and general anesthesia, preoperative epidural analgesia or continuous nerve blocks for upper limb amputations and for patients who are poor candidates for neuraxial anesthesia should be strongly considered for injury limited to a limb. This consideration is most important whenever the regional anesthesia techniques are extended into the postoperative period to provide analgesia.

Because of limited patient cooperation, high-quality nursing care and well-trained anesthesiologist are mandatory prerequisites for the use of regional anesthesia safely in all the perioperative period.

References


