Research Article

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A Few Words about Neuraxial Anesthesia

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Abstract

Neuraxial anesthesia includes three methods of central regional anesthesia; epidural, spinal or subarachnoid or intrathecal and combined spinal-epidural anesthesia. They are performed after the application of lidocaine topically, by introducing special needles and catheters between the respective vertebrae. The risk of application still exists, but is generally considered relatively low and predictable. The reduction in pain provided by neuraxial analgesia consequently also reduces the negative effects of pain.

Keywords: Neuraxial Anesthesia, Indications, Contraindications, Blockade, Health Care.

Introduction

Neuraxial anesthesia may be indicated as the primary anesthetic for major or minor surgeries or as an adjunctive anesthetic for intraoperative pain control in addition to general anesthesia (Harrison et al., 2018). It is most useful as the primary anesthetic in surgeries involving the abdomen, perineum, or lower extremities. Neuraxial anesthesia is also an option for thoracic and upper abdominal surgeries, although it may not be the optimal choice for a patient with respiratory insufficiency or during prolonged surgeries resulting in compromised respiratory function (such as pneumoperitoneum). This is related to the fact that these patients rely heavily on accessory muscles of inspiration, which are often weakened with high neuraxial anesthesia, despite minimal changes in tidal volume. In these situations, an epidural or spinal may be useful to supplement general anesthesia in providing postoperative pain relief. Continuous epidural anesthesia is also widely used in labor analgesia.

Regional anaesthesia in the form of neuraxial block (spinal or epidural) has been shown to be a safe form of analgesia for major abdominal surgery (Whitlock & Pardo, 2018). Data from the National Audit Project of the Royal College of Anaesthetists was the largest study to date looking at complications arising following neuraxial blockade. The national audit produced a denominator of around 700,000 central neuraxial blockade procedures. Of these, 46% were spinals and 41% epidurals, and 45% were performed for obstetric indications and 44% for perioperative analgesia. The incidence of permanent injury due to Central Neuraxial Blockade (CNB) (expressed per 100,000 cases) was 'pessimistically' 4.2 (95% confdence interval 2.9–6.1) and 'optimistically' 2.0 (95% confdence interval 1.1–3.3). These are equivalent to 1 in 24,000 and 1 in 54,000, respectively. This national audit looked at all types of surgery and there is minimal safety data specifc to hepatic surgery.

Indications

Neuraxial anesthesia may be indicated as the primary anesthetic for major or minor surgeries or as an adjunctive anesthetic for intraoperative pain control in addition to general anesthesia (Harrison et al., 2018). It is most useful as the primary anesthetic in surgeries involving the abdomen, perineum, or lower extremities. Neuraxial anesthesia is also an option for thoracic and upper abdominal surgeries, although it may not be the optimal choice for a patient with respiratory insufficiency or during prolonged surgeries resulting in compromised respiratory function (such as pneumoperitoneum). This is related to the fact that these patients rely heavily on accessory muscles of inspiration, which are often weakened with high neuraxial anesthesia, despite minimal changes in tidal volume. In these situations, an epidural or spinal may be useful to supplement general anesthesia in providing postoperative pain relief. Continuous epidural anesthesia is also widely used in labor analgesia.

Contraindications

Absolute contraindications to neuraxial anesthesia include patient refusal, bleeding diathesis, elevated intracranial pressure (except pseudotumor cerebri), infection at site of injection, hypovolemia, and indeterminate neurologic disease (Harrison et al., 2018).

Other disease processes are discussed as relative contraindications and clinical judgment should be used in these situations. Severe aortic or mitral stenosis or left ventricular outflow obstruction when combined with spinal or rapidly achieved epidural anesthesia may result in sudden, severe hypotension and possible cardiac ischemia. These effects are secondary to a sympathetic blockade, leading to vasodilation, venous pooling, and ultimately decreased preload. However, neuraxial anesthesia can be used safely with close monitoring, and when possible, a slowly dosed epidural would be preferred over spinal anesthesia to avoid the abrupt decline in blood pressure.

Sepsis or distant infections have been implicated in predisposing the patient to meningitis, epidural abscess, or Central Nervous System (CNS) infection via hematogenous spread following neuraxial anesthesia. While it is recommended to exercise caution in such patients, it is generally not contraindicated to perform a neuraxial block as it may actually be a better choice for some sick patients.

Chronic back pain or preexisting neurological deficits and paresthesia due to prior neurologic disease are generally not contraindications; however, prior symptoms or exacerbations of a disease state may mask or imitate side effects or complications associated with the procedure itself. Some practitioners would defer from performing neuraxial or regional anesthesia on such patients. It is, therefore, important to thoroughly interview and examine the patient and document reported findings prior to performing the neuraxial blockade. Also, in many patients with prior lumbar surgeries the ligamentum flavum may not be intact. Therefore, the provider should not rely on loss of resistance technique to find the epidural space and consideration should be made to enter at a level remote from previous surgery.

Preparation

Preparation for neuraxial anesthesia, like general anesthesia, should begin with a discussion with the patient and obtaining informed consent (Harrison et al., 2018). The patient interview should include specific questions such as whether there is a history of anesthetic complications, prior difficult placement of epidural or spinal anesthesia, history of bleeding disorders or thrombocytopenia, whether the patient is taking any anticoagulant medications, and history of spine disorders (ie, scoliosis) or surgeries. The provider should then discuss the benefits and potential complications associated with neuraxial blockade. These include the rare but serious complications such as bleeding, infection, or temporary nerve damage, as well as more common but less severe risks such as post dural puncture headache and mild pain.

Lumbar neuraxial anesthesia may be performed completely awake, with minimal sedation or under general anesthesia. Performing this block under general anesthesia, however, remains controversial. The reasoning is that the patient would be unable to verbalize pain or paresthesia during injection, symptoms that are associated with intraneural injection and postoperative neurological deficits. On the other hand, providing deep sedation or general anesthesia would reduce sudden patient movement, allowing for easier needle placement and less chance of nerve damage. Epidurals and spinals of the thoracic and particularly of the cervical spine should be placed in awake patients. The exception to this is the pediatric population, in which case neuraxial anesthesia is often performed under general anesthesia secondary to poor patient cooperation.

Pharmacological premedication, typically in the form of midazolam and fentanyl, is often beneficial prior to performing regional anesthesia. Premedication is avoided for labor epidurals, so it is essential to discuss expectations and verbally guide the patient through the procedure if desired. In situations where premedication is not used, patients should be provided with ample local anesthetic skin infiltration.

Blockade

Anesthetic techniques can be combined to meet patient or surgical goals (Schofield & Campbell, 2021). For example, a patient with subarachnoid hemorrhage who requires diagnostic cerebral angiography may initially receive MAC. If the imaging reveals a cerebral aneurysm requiring endovascular coiling, the anesthesia provider may be asked to convert to general anesthesia to provide patient immobility and control of ventilation during the procedure.

Neuraxial and peripheral nerve blockade may be combined with general anesthesia to provide long-lasting postoperative analgesia following a surgical procedure that may not be amenable to regional anesthesia alone. A 2013 systematic review documented that, in a broad range of surgical procedures, use of local infiltration or peripheral nerve block in addition to general anesthesia improved postoperative pain scores and decreased opiate consumption. This result may be directly due to analgesia provided by the technique or by "preventive analgesia," which is defined as analgesia lasting longer than 5.5 half-lives of an analgesic drug. Even use of a peripheral nerve block in addition to a singleshot spinal block improves postoperative analgesia for many surgeries of the lower extremity.

The addition of a regional technique to general anesthesia may reduce intraoperative blood loss and, in some situations, the rate of perioperative transfusion. Addition of neuraxial or peripheral nerve blockade to general anesthesia also reduces rates of postoperative chronic pain. A meta-analysis of systematic reviews did not find a mortality rate benefit for the addition of neuraxial anesthesia to general anesthesia. The same meta-analysis suggested that neuraxial anesthesia was associated with lower 30-day mortality rates compared to general anesthesia alone in patients with an intermediate risk of cardiac complications.

There is increasing emphasis on improving patient outcomes not just in the immediate term (e.g., intraoperatively) but facilitating in-hospital recovery, mitigating risks for development of postoperative chronic pain, and improving long-term survival.

Labour

The key to managing poor blocks is early detection (Monteiro et al., 2019). All mothers who have had an epidural block in labour should be checked by the anaesthetist within 20–30 minutes of the first dose and the level of analgesia tested with a suitable stimulus. Continued review of the patient and the efficacy of epidural analgesia is mandatory throughout subsequent labour. Any complaint of persistent pain at any time during the labour should prompt further testing and review. Dislodgement or disconnection of the epidural catheter should first be excluded by visual inspection of the insertion site and infusion set. Confirmation of block height and assessment of the distribution of pain may enable the anaesthetist to determine the appropriate management strategy. If an epidural cannot be made to function adequately within an hour of troubleshooting, the anaesthetist and woman should consider the benefit of resiting it.

Generalised abdominal pain with uterine contractions may indicate an insufficient height of neuraxial block, which should extend to a dermatomal level of T8–10 during the first stage of labour. This may be managed by the administration of an additional dose of the epidural local anaesthetic–opioid mixture (a bolus of up to 20 ml has been suggested). This should preferably be given manually, as this is thought to aid wider spread in the epidural space. Occasionally, a solution containing either stronger local anaesthetic or fentanyl, or both, might be required for intense pain during augmented labour.

Perineal pain that results from failure of epidural analgesia to provide effective blockade of the larger sacral nerve roots that are less penetrable by neuraxial drugs (sacral sparing) may respond to topping up in the sitting position, with either the standard low-dose epidural solution or a higher-concentration local anaesthetic (e.g. 0.25% bupivacaine), or with fentanyl (50–100 μg). Supplementation with a pudendal nerve block may be used if delivery is imminent. A combined spinal–epidural (CSE) should be considered in situations when the pain is resistant to treatment.

A limited unilateral block is usually due to insertion of an excessive amount of epidural catheter, and may be rectified by pulling back the catheter to leave 3–5 cm in the epidural space. Unfortunately, once a 'track' has been established for the local anaesthetic solution, it may persist despite this manoeuvre, and the only solution may be to remove the catheter and re-site it in a different space. Even if the catheter was originally inserted to the optimum distance, the possibility of it being drawn further into the epidural space should not be discounted; this has been shown to happen as a result of traction imposed by movements of the vertebrae and activity of the spinal muscles.

LMWH

LMWHs (Low-Molecular-Weight Heparin) are used for both prophylaxis and treatment of arterial and venous thromboembolism (Hall & Chantigian, 2020). The elimination half-life of LMWH is 3 to 6 hours after subcutaneous injection in patients with normal renal function. With severe renal insufficiency, the half-life of LMWH can be up to 16 hours. At least 12 hours should elapse before performing any neuraxial techniques (e.g., placement or removal of an epidural catheter) to decrease the likelihood of a spinal hematoma forming after low-dose prophylaxis with LMWH (e.g., enoxaparin 30 mg BID or 40 mg once daily). If high-dose LMWH is used for therapeutic anticoagulation (e.g., enoxaparin 1 mg/kg BID or 1.5 mg/kg once daily), you should wait at least 24 hours to decrease the likelihood of a spinal hematoma forming. A postprocedure dose of enoxaparin should usually be given no sooner than 4 hours after epidural catheter is removed. In all cases, the benefitrisk of thrombosis and bleeding should be made. If the patient has back pain and unexpected neurologic paralysis, a workup for an epidural hematoma should be performed. This case demonstrates a benign condition in which the sympathetic nerve supply to the eye is blocked (Horner syndrome [triad of miosis, ptosis, and anhidrosis]). This occasionally develops after a lumbar epidural anesthetic, even when the highest dermatome level blocked is below T5. It may be related to the superficial anatomic location of the descending spinal sympathetic fibers that lie just below the spinal pia of the dorsolateral funiculus (which is within diffusion range of subanesthetic concentrations of local anesthetics in the cerebrospinal fluid) as well as increased sensitivity to local anesthetics during pregnancy.

Epidural Hematoma

Epidural hematomas and epidural abscesses are quite rare (Gaiser, 2015). Severe back pain and/or leg weakness that is greater than expected (or the recurrence of weakness after partial recovery of a neuraxial block) are presenting symptoms of spinal cord compression. Epidural hematomas can develop within 12 hours of a neuraxial procedure, whereas epidural abscesses usually take days to develop and also present with fever and leukocytosis. These conditions need imaging (e.g., magnetic resonance imaging [MRI]) and neurosurgical consultation. Studies have shown that when spinal cord decompression occurs within 8 hours of the onset of paralysis, neurologic recovery is significantly better than after 8 hours. Although epidural hematoma formation is rare, clotting disorders and perhaps marked difficulty in placing a block could lead to epidural bleeding and hematoma formation. Because the preeclamptic patient may develop a coagulopathy, one should carefully evaluate her coagulation status before initiating a regional block. Most anesthesiologists would evaluate a platelet count in the preeclamptic patient and look for any clinical signs of unexplained bleeding before initiating a regional block. Because an epidural blood patch often is performed with 20 mL of blood, the epidural hematoma that causes spinal cord compression is probably significantly greater.

Hypotension

Hypotension is caused by one of two mechanisms: a decrease in systemic vascular resistance or a decrease in cardiac output (Gaiser, 2015). In obstetric anesthesia, there are two main causes of hypotension: aortocaval compression and sympathectomy from neuraxial anesthesia. If the parturient

lies on her back, the gravid uterus compresses the vena cava against the lumbar vertebra, decreasing venous return and cardiac output. This usually occurs after 20–24 weeks gestation. Aortocaval compression may be avoided by tilting the uterus to the left (uterine displacement) by placing a wedge beneath the right hip. Both epidural and spinal anesthesia can produce a sympathectomy, which decreases systemic vascular resistance. The uterus does not autoregulate blood flow, so blood flow is dependent upon the blood pressure.

Originally, fluid loading with crystalloid solutions prior to neuraxial anesthesia for cesarean delivery was thought to decrease the incidence and severity of hypotension. However, fluid loading with these solutions does not prevent the development of hypotension. Colloid solutions have been demonstrated to decrease the incidence and severity of hypotension prior to neuraxial anesthesia. Colloid solutions are more expensive and have the risk of increased anaphylaxis. The routine administration of colloid prior to epidural or spinal anesthesia is not done. Prophylactic administration of vasopressors prior to neuraxial anesthesia is not recommended because they may cause hypertension. Most practitioners do not administer a fluid load prior to the initiation of epidural analgesia for labor.

Organ Transplantation

Proper anesthesia management requires a detailed understanding of the physiology of the transplanted heart and the comorbidities associated with OHTx (Orthotopic Heart Transplantation) (Baisden, 2017). After a comprehensive preoperative examination, standard premedication should be given as in non-transplant patients. As in most cases, the type of anesthesia utilized is dictated by the surgical requirements. General, neuraxial, and regional anesthesia as well as monitored anesthesia care have all been safely used in this patient population. A valid concern with the use of neuraxial anesthesia is that acutely decreasing preload may lead to severe hypotension in a patient who is “preload dependent.” Intravascular volume administration prior to neuraxial block may help to augment the severity of hypotension, but some recommend avoiding neuraxial blocks in OHTx recipients due to the unpredictability of the hemodynamic response.

Intraoperative monitoring with standard ASA monitors may be all that is required for patients following OHTx. If invasive monitors are planned in the setting of predicted large fl uid shifts, one must weigh the risks of infection versus the benefits of invasive monitoring techniques. Strict care must be taken to ensure that complete aseptic technique is used with the insertion of invasive monitors due to the increased risk of infection in patients on immunosuppressive regimens. As opposed to a pulmonary artery catheter, transesophageal echocardiography may be a more helpful monitor to evaluate volume status and cardiac contractility with a decreased risk of infection.

Medication administration by the anesthesia provider must also be carefully considered. The transplanted organ does maintain a normal density of intrinsic adrenergic receptors and direct-acting drugs such as epinephrine and norepinephrine are often the most useful in treating hypotension. Intravenous fluid boluses should also be considered early in the management of hypotension. The muscle relaxant used to maintain balanced anesthesia should be chosen with caution as well; cis -atracurium is often an excellent choice due to the fact that elimination is not affected by either renal or hepatic dysfunction. The choice of reversal of muscle relaxation must also be taken seriously because there are numerous reports of neostigmine-induced asystole following OHTx. Some providers avoid the use of neuromuscular blocking drugs entirely to avoid this described complication.

Trauma Patient

Regional anesthesia represents a potentially invaluable tool for pain management in the trauma patient (Merritt et al., 2014). Regional or neuraxial techniques can be used as the primary anesthetic for patients with trauma limited the extremities, and it can supplement the anesthetic and postoperative pain control of patients with more extensive injuries including thoracoabdominal trauma. Strong evidence exists for the benefit of regional and neuraxial anesthesia in pain control, patient satisfaction, decreased physiologic stress response to surgery, improved return of bowel function after laparotomy, decreased opioidrelated side effects, and possibly improved pulmonary mechanics, and decreased development of chronic pain.

Nevertheless, there are multiple common concerns that prevent the widespread use of regional and neuraxial anesthesia in trauma patients. Neuraxial techniques may be contraindicated in trauma patients due to factors such as hypovolemia, hemodynamic instability, the presence of increased intracranial pressure, patient refusal or inability to obtain consent, coagulopathy, thrombocytopenia or pharmacologic anticoagulation, patient inability to cooperate with the procedure (e.g., the anesthetized, disoriented, or intubated/sedated patient), spinal trauma, and patients at risk of compartment syndrome, e.g., crush injuries or tibial plateau fractures. Many of these concerns are lessened in consideration of peripheral nerve blockade compared to neuraxial. For example, many peripheral nerve blocks can be safely performed in hypovolemic patients or those patients receiving low-molecular-weight heparin where neuraxial techniques may not be suitable.

Single-shot Epidural Techniques in Children

Single-shot epidural techniques are typically administered in younger children at the caudal epidural space (Rodriguez-Diaz, 2022). Because administering a local anesthetic at the caudal or even lumbar epidural level will not reach adequate thoracic levels, single-shot caudal techniques are mostly limited to the use of hydrophilic opioids and in particular preservative free morphine. Morphine, easily administered via the caudal space in younger children (typically but not limited to children <5 years of age), will provide a long-lasting analgesic effect. Its peak analgesic effect is 4 to 7 hours, and its duration of action has been reported up to 24 hours. Dose can range from 30mcg/kg to as high as 100mcg/kg. Dose should be halved

for neonates. Even though neuraxial opioids do not offer the potential advantages of a sympathetic thoracic epidural block achieved with local anesthetic agents, epidurally administered opioids have been shown to provide excellent analgesia, pulmonary function, and early ambulation. Side effects related to neuraxial opioids include nausea and vomiting, pruritus, somnolence, respiratory depression, and urinary retention. Close postoperative monitoring for 24 hours is mandatory when neuraxial opioids are used, importantly to identify any potential respiratory depression. Alternative drugs, such as the alpha 2 receptor agonist clonidine, ketamine, and magnesium have been used in the epidural space to minimize undesirable side effects of opioids, such as respiratory depression, and to prolong analgesic effects.

Insertion of an epidural catheter can lead to several complications such as misplacement, knotting, and migration, (especially if advanced too far), rupture, infection, leakage, epidural hematoma, and neurologic injury. The true incidence of neuraxial anesthesia complications is not known. Severe complications of epidural catheters, defined as infection (epidural abscess), include local anesthetic toxicity, cardiac arrest, drug error causing harm, or neurologic injury. In pediatric patients, complications have been estimated around one in 2000 patients in one study, with permanent neurologic injury at one in 10,000 patients whereas another reported no neurologic complication in 150,000 single-shot caudal anesthetics. At the moment, it does not appear that children are at higher risk from neuraxial techniques than adults.

Conclusion

When performing neuraxial anesthesia or spinal/epidural puncture, patients treated with antithrombotic agents to prevent thromboembolic complications have an increased risk of developing an epidural or spinal hematoma that may result in long-term or permanent paralysis. The risk of such events may be increased by postoperative use of permanent epidural catheters or concomitant use of drugs that affect hemostasis. The risk may also be increased by traumatic or repeated epidural or spinal puncture. Patients must be closely monitored for signs and symptoms of neurological disorders. If a neurological deficit is observed, urgent diagnosis and treatment are required. The physician should consider the potential benefits against pre-neuraxial intervention in patients receiving anticoagulant therapy or receiving anticoagulant therapy for thromboprophylaxis.

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