16 Regional Anesthesia Complications Related to Acute Pain Management

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There is a large variety of available routes for administration of analgesic drugs to manage postoperative pain; these include: enteral (oral, sublingual, buccal, transmucosal), rectal, parenteral [subcutaneous, intramuscular (i.m.), intravenous (i.v.)], surface (topical, transdermal), cavity (intranasal, inhalational, intra-articular), and neural (neuraxial and peripheral) routes. Table 16-1 shows the regional techniques available to manage postoperative pain. The problems associated with regional techniques generally are covered elsewhere in this book; these include technique-related issues, infection, nerve injury, systemic local anesthetic (LA) toxicity, etc. Also, it is clear that "epidural analgesia" is not a generic term. Its effects on outcome and complications may differ depending on whether epidural injections consist of opioids, LAs, or both. In addition, the insertion site for the epidural catheter (lumbar, low thoracic, or high thoracic) will significantly alter physiologic effects when LAs are used.

This chapter will outline the complications associated with the use of regional techniques for the management of pain in the postoperative period in inpatients and those undergoing day surgery.

Neuraxial Blocks and Risks of Severe Neurologic Complications

Severe complications caused by central neuraxial blocks (CNBs) are believed to be extremely rare, but the incidence is probably underestimated. In a recent Swedish retrospective study of complications during 1990–1999 after CNB (1,260,000 spinal blocks and 450,000 epidural blocks), 127 severe neurologic complications were reported.[1] These included spinal hematoma (n = 33), cauda equina syndrome (n = 32), meningitis (n = 29), epidural abscess (n = 13), and miscellaneous (n = 20). Permanent neurologic damage was observed in 85 patients. The incidence of complications after spinal blockade was within 1:20,000–30,000 in all patient groups. The incidence after obstetric epidural blockade was 1:25,000; in the remaining patients it was 1:3600 ($P < .0001$). In this study, a 55 times greater risk of spinal hematoma was noted after epidural block in female patients undergoing knee arthroplasty (1:3600) as compared with patients receiving epidural block for obstetric indications (1:200,000) ($P < .0001$).

B. T. Finucane (ed.), *Complications of Regional Anesthesia*

TABLE 16-1. Regional techniques for postoperative analgesia

- Central blocks (epidural, spinal, combined spinal–epidural)
- Peripheral blocks
  Proximal and distal nerves
  Perineural – during surgery (amputation)
  Intercostal, paravertebral
- Incisional (subcutaneous, subfascial)
- Intraarticular, intrabursal
- Intraperitoneal
- Supraperiosteal

This study is the most comprehensive retrospective study performed to detect serious neurologic complications after CNB. The authors concluded that more complications than expected were found. Complications occur significantly more often following epidural than spinal blockade, and these complications are different. Obstetric patients carry a significantly lower incidence of complications. Osteoporosis was proposed as a previously neglected risk factor. One-third of all spinal hematomas were seen in patients receiving thromboprophylaxis in association with neuraxial block in accordance with the current guidelines and in the absence of any previously known risk factors. Consequently, adherence to guidelines regarding low-molecular-weight heparin may reduce but not completely abolish the risk of spinal hematoma after neuraxial block on the surgical wards. Close surveillance after central neuraxial blockade is mandatory for safe practice. More females than males experience osteoporotic hip fractures and more females need knee or hip arthroplasty. Osteoporosis not only causes a higher number of hip fractures – the spine is also affected with vertebral deformities and fractures. Moreover, the osteoporotic vertebra is enlarged, causing narrowing of the spinal canal. A large number of female patients with pathologically altered spines are therefore subject to CNB.

In this study, only 13 cases of epidural abscess were found, indicating an incidence significantly lower than previously reported.[2,3] The incidence of epidural abscess may be underestimated because these complications may appear late after the patient has left the surgical ward. Risk factors for infection were present in 75% of the patients.

Organizational Issues – Role of Acute Pain Services

Providing effective analgesia for patients undergoing major surgery is challenging for most anesthesiologists. Continuous thoracic epidural analgesia using a low-dose LA–opioid combination has the potential to provide effective dynamic pain relief, early mobilization, and rehabilitation for patients undergoing major upper abdominal or thoracic procedures. However, in a busy surgical ward, it is not uncommon for epidurals to be ineffective in providing dynamic pain relief. Rarely and catastrophically, major complications occur.[4]

Regional techniques can result in a number of complications, some of which are of major concern because of their potential to cause permanent neurologic damage. These problems can be related to the presence of the catheters in the epidural, subarachnoid, or perineural space, or to drugs infused or drug errors. The availability of acute pain services (APSs) can help in early recognition of these rare complications and to prevent serious harm.

Implementation of invasive analgesic techniques such as epidural anesthesia may lead to increased treatment-related morbidity which will depend on the drugs and adjuvants administered in the epidural catheter and on the monitoring routines. This

may range from pruritus to serious complications such as epidural hematoma. Provision of safe analgesia is one of the main objectives of an APS; however, there is very little literature on the role of APSs in preventing or reducing these complications.[5-7] Werner et al.[5] reviewed the literature on APSs, the 44 audits and four clinical trials containing outcome data included 84,097 postoperative patients. The overall incidence of complications (total = 43,576; epidural analgesia = 12,212) was 0.5%–1.2%, comprising in most cases opioid-related respiratory depression.[8,9] The incidence of serious neurologic complications related to the epidural analgesia was reported in six audits (n = 12,940) and in one review. Several authors have emphasized that epidural analgesia, with continuous infusion of LAs on the wards, requires visits including gross neurologic examination by an APS at least once a day.[10]

Neurologic Complications on Surgical Wards

Neurologic injuries caused by neuraxial blockade are in two categories: those that relate to performing the block and those related to an inadequate organization of the postoperative surveillance at the postanesthesia care unit (PACU), the high-dependency unit, or the ward. The review by Werner et al.[5] showed that serious catheter-related epidural complications reported included one case of cauda equina syndrome with persisting urinary incontinence (n = 5602),[11] two cases of meningitis (n = 2287),[12] three cases of intravascular migration of the epidural catheters (n = 1062),[13] and five cases of intradural migration of the catheter (n = 4958).[8,13,14]

Technical Incidents

In a study by Chen et al.,[15] 53 incidents were reported during 1 year in 1275 patients managed by an APS. Twenty-eight incidents were related to malfunctioning infusion devices and 15 incidents to erroneous drug dosing. Thirty-eight of the incidents were detected by the APS and the anesthesiologist. In a safety-assessment study, potentially severe complications were discovered in 0.5% of the patients (16 of 3016), without sequelae.[8]

Urinary Retention

Surgery, anesthesia, and postoperative analgesia are factors that contribute to postoperative urinary retention, which may lead to urinary tract infections. Treatment by an indwelling catheter for a prolonged period, however, increases the incidence of urinary tract infections, septicemia, and mortality.[5]

Hypotension

The reported incidence of clinically significant hypotension requiring APS intervention after epidural analgesia ranges from 0.7%[16-18] to 7.4%.[19] The use of epidural LA drugs is associated with hypotension because of blockade of the sympathetic chain. If the block height reaches the cardiac innervation (between T1 and T5), there may be a marked hypotensive and bradycardic response, particularly in the presence of hypovolemia. Wheatley et al.[4] combined the results of three studies involving nearly 9000 patients and showed that the incidence of hypotension during epidural infusion of LA was 0.7%–3% depending on the concentration used (0.0625%–0.25% bupivacaine) and the criteria for hypotension.[17,20,21] Use of patient-controlled epidural analgesia (PCEA) resulted in a 6.8% incidence of hypotension.[4]

Complications Caused by Excessive Motor Blockade

Excessive lower limb motor blockade is uncommon with low doses of local anesthesia solutions. Scott et al.[22] reported an incidence of 3% with bupivacaine–fentanyl

combination. Excessive motor block may result in the development of pressure areas on the heels[23–25] and deep venous thrombosis.[9] Persistent motor blockade of one or both lower limbs in a patient receiving a low-dose combination LA–opioid thoracic epidural should always be treated with suspicion. Stopping the epidural infusion normally results in neurologic improvement within 2 hours. If this does not occur, consideration should be given to excluding a spinal hematoma or abscess. Ropivacaine may produce less motor blockade compared with an equianalgesic dose of bupivacaine, especially if used in low concentrations (0.1%) with fentanyl ($2\,\mu g\,mL^{-1}$).[26]

The literature review by Werner et al. showed that the incidence of clinically significant motor blockade (Bromage grade >0), impeding normal ambulation, was significantly increased with lumbar versus thoracic catheters (7%–50% and 1%–4%, respectively).[11,14,18] An unusually prolonged, unilateral motor block in two patients, lasting 4–10 days, was reported in one audit.[9] Subjective motor weakness was reported in up to 16%–21% of patients (the level of the epidural catheter placement was not reported).[17]

Catheter-Incision Congruent Analgesia

The importance of the site of epidural catheter cannot be overemphasized; the use of "catheter-incision congruent analgesia" involves the placement of epidural catheter corresponding to the dermatomes of the surgical incision. For patients with coronary artery disease who are undergoing upper abdominal or thoracic surgery, the use of thoracic epidural analgesia may provide several physiologic advantages by increasing coronary flow to ischemic areas and attenuating sympathetically mediated coronary vasoconstriction.[27–29] The use of lumbar epidural analgesia in these patients may result in increased sympathetic activity in upper thoracic segments and may increase myocardial oxygen consumption.[27,30] A metaanalysis showed a significant decrease in the incidence of postoperative myocardial infarction with the use of thoracic (congruent) but not lumbar (incongruent) epidural analgesia.[31] A review of the literature comparing epidural analgesia with systemic opioids to assess return of postoperative bowel function showed that all nine trials incorporating "catheter-incision congruent" epidural analgesia noted earlier return of gastrointestinal function, whereas only one of seven trials with "catheter-incision incongruent" epidural analgesia noted earlier return of gastrointestinal function.[32]

Catheter Migration

The tip of the epidural catheter can migrate intrathecally (i.t.) or intravascularly. This must be considered before any bolus dose is administered in the epidural catheter by careful aspiration; a test dose of LA containing epinephrine can also provide evidence of i.v. migration by producing a transient tachycardia. These techniques, and the use of low-dose LA–opioid infusions, can prevent dramatic complications, such as total spinal anesthesia and seizures.[33,34] Unintentional subdural catheter placement or migration can also lead to a high block, requiring intubation.[35] The incidence of i.t. and i.v. migration has been reported as 0.15%–0.18%.[4,36,37]

Knotting of Epidural Catheter

The estimated incidence of knotting of the epidural catheter is 0.0015%. There are 14 case reports in the literature since 1965.[38] The length of the catheter introduced in the epidural space and the design and material of the epidural catheter have been proposed as possible causes. It is generally recommended that the length of catheters in the epidural space should be less than 5 cm.[38]

Adverse Events Related to Epidural Drug Administration

Drug Errors

The most common drugs involved in errors are LAs and opioids; adjuvants such as clonidine and epinephrine are also involved in errors. All these drugs carry the potential for serious adverse effects. Drug errors can also occur when a wrong drug is administered via the epidural catheter. The incidence remains unclear – glucose,[39] antibiotics,[40] thiopentone,[41,42] potassium chloride[43–45] (resulting in paraplegia), and total parenteral nutrition[46] have all been inadvertently injected. The use of pharmacy-prepared or commercially prepared solutions, extreme care with labeling of epidural catheters and drugs, checking procedures, and the use of dedicated pumps should help avoid these problems.

Central Nervous System Toxicity

The incidence of convulsions, as a result of high plasma concentrations of free LAs, was reported to be 0.01%–0.12% for bupivacaine when 16,870[47] and 40,010[48] epidural blocks were assessed.[4]

Respiratory Depression – Are Lipophilic Drugs Safer?

The adverse effect of most concern with epidural opioids is respiratory depression. Nearly all available opioids have been used epidurally in the management of postoperative pain. Data from large studies and from several reviews suggest that morphine is by far the most extensively studied opioid worldwide.[49–52] A 17-nation European survey showed that 12 different opioids were used routinely to manage postoperative pain. Morphine and fentanyl are the most frequently used opioids in Europe.[53] Highly lipid-soluble drugs such as fentanyl and sufentanil have a more rapid onset and shorter duration of effect than hydrophilic drugs such as morphine. The long duration of analgesia of epidural morphine allows it to be used as an intermittent bolus dose twice a day, whereas opioids such as fentanyl and sufentanil are better suited for continuous infusion because of their short duration of analgesia.

On the basis of pharmacologic models proposed for spinal opioid transport, the risk of late-onset respiratory depression is high with hydrophilic morphine. In contrast, lipophilic opioids such as fentanyl and sufentanil are considered safe because of segmental localization; minimal drug is available for rostral migration in cerebrospinal fluid (CSF) to reach medullary respiratory centers by diffusion and bulk flow. This has led to the widespread use of fentanyl as a safe opioid for epidural administration. However, the earlier belief that continuous infusions of epidural fentanyl do not cause late-onset respiratory depression has been shown to be incorrect.[54–59] The use of continuous epidural fentanyl infusions has been associated with three deaths caused by respiratory arrest. Two of the patients had sleep apnea syndrome.[60] Similarly, respiratory depression was reported in several patients on postoperative days 2, 3, and 4 in patients receiving epidural sufentanil–bupivacaine infusion for analgesia after major surgery.[61]

In an editorial, Eisenach[62] has stated that the belief that highly lipid-soluble drugs stay fixed at their site of location and do not move in CSF is a myth. Several case reports have demonstrated acute and life-threatening respiratory depression following i.t. fentanyl, sufentanil, and meperidine. Lipid-soluble drugs, be they opioids or LAs, do move rapidly and extensively in CSF and can produce patient harm.[62] There is a widespread misconception that any opioid administered epidurally or i.t. will produce analgesia by a selective spinal mechanism. Recent data suggest that increasing lipid solubility decreases the spinal cord bioavailability of spinally administered opioids. These data help to explain many clinical studies that have demonstrated that the

analgesic effect of spinally administered lipid-soluble opioids is partly, if not exclusively, attributable to plasma uptake and distribution to brainstem opioid receptors.[63] The method of lipophilic opioid administration may also be important. It has been demonstrated that epidural fentanyl infusion produces analgesia by uptake into plasma and redistribution to brain and peripheral opioid receptors, whereas fentanyl bolus produces analgesia by a selective spinal mechanism.[64]

The choice of opioid may also depend on hospital or state nursing regulations regarding administration of opioids in epidural or i.t. catheters. This may be one reason why intermittent administration of morphine in epidural catheters is common in countries where nurses are allowed to inject drugs. Conversely, epidural infusion techniques are popular in some countries where nurses are not allowed to inject drugs in epidural or i.t. catheters.

Problems with Intraspinal Opioids and LA Combinations

Epidural LA drugs have many advantages, such as blockade of sympathetic and hormonal responses to surgery and pain and lack of inhibition of bowel function. However, motor block may prevent postoperative mobilization and sympathetic block can result in hypotension. Adjuvants such as opioids, clonidine, and epinephrine have been added to improve analgesia, reduce morbidity, and reduce LA dose and side effects.

It is generally agreed that epidural analgesia using LA and opioid combinations is highly effective in reducing movement-associated pain. However, the optimum combination that has an opioid-sparing synergistic effect, without delaying mobilization, is yet to be established. A variety of factors influence the rate of epidural analgesia infusion that is necessary for effective analgesia. These include the site and type of surgery, type of pain (labor versus postsurgery), choice of opioid and its loading dose, the volume of injectate, the concentration of LA, and patient characteristics that influence epidural pharmacokinetics and pharmacodynamics of the given opioid. Sitting of the catheter tip in the epidural space is also important, thus, bupivacaine 0.1% with fentanyl given through a lumbar catheter was associated with a high incidence of lower limb weakness[65] whereas motor weakness was insignificant when LA (0.1%–0.2% bupivacaine) was administered at the thoracic level.[66,67]

In general there is no agreement about the most suitable drug combinations and dosages. A recent questionnaire survey of United Kingdom epidural practice showed that 103 LA–opioid solutions were used at the 74 centers that responded. In one center, seven different solutions were used.[68] Clearly, there is a need for rationalizing this practice because it has implications for safety, nursing workload, economic costs, and audit data collection.

Patient-Controlled Epidural Analgesia

PCEA may improve analgesia, patient satisfaction, and safety compared with epidural technique using bolus administration or infusion. It has been suggested that epidural PCA with opioids results in a more rapid recovery and shorter hospitalization than i.v. PCA or i.m. opioids.[69] Patients have increased satisfaction partly because of a sense of control and the flexibility to increase analgesic demand to match pain during movement.

Potential benefits of PCA have to be balanced against potential risks. Excessive self-administration of opioid may result in respiratory depression, and of LA in a high incidence of hypotension or motor block. Self-administration of opioids and LAs could exacerbate the effects of displaced epidural catheter into the intravascular or i.t. space resulting in high spinal block, systemic toxicity, or respiratory depression.[58,70]

A report based on experience with 1030 surgical patients using PCEA with bupivacaine and fentanyl showed that PCEA provided effective postoperative analgesia for rest and movement-related pain. The study included abdominal, thoracic, gynecologic, urologic, vascular, orthopedic, and plastic surgical procedures. Although the incidence of side effects was quite low, hypotension (6.8%) and respiratory depression (0.3%) did occur.[58] In a survey of 1057 patients (3858 treatment days), PCEA with bupivacaine–fentanyl was associated with 0.19% severe respiratory depression and one patient was unrousable.[59] Appropriate surveillance is therefore necessary for patients receiving PCEA.

In general, there is a lack of randomized studies to identify the best lipophilic opioid. The ideal combination of LA and opioid for PCEA is unknown. Further studies are needed to determine optimal analgesic solution, background infusion rates, and lockout intervals. Studies are also necessary to evaluate the cost–benefit ratio of this technique.

Safety of Epidural Versus Intrathecal Opioids

The efficacy, optimal dose, duration of analgesia, and adverse effect profile of epidural opioids have been extensively documented; however, there is a paucity of similar information for i.t. opioids. The i.t. route is a direct one because there is no dura to be penetrated and the drug is deposited close to its site of action – the opioid receptors. Intrathecal administration of opioids immediately produces a high CSF concentration of the drug that is dose dependent. Vascular reabsorption of opioids after i.t. administration does occur to some degree, but is clinically irrelevant. Compared with the i.t. route, epidural administration is complicated by pharmacokinetics of dural penetration, epidural fat deposition, and systemic opioid absorption. Intrathecal administration of opioids has the advantages of simplicity, reliability, and low-dose requirements. To compensate for the effects of systemic uptake and fat sequestration, the epidural dose of morphine is approximately 10- to 20-fold greater than that required for i.t. injection.[71]

Recently it is has been demonstrated that doses as low as 0.1–0.5 mg may provide adequate analgesia after abdominal, orthopedic, and thoracic surgery.[72–77] There is now convincing evidence that doses less than 0.2–0.3 mg provide excellent postoperative analgesia. A systematic review of 15 randomized, controlled trials of i.t. opioids in patients undergoing cesarean section with spinal anesthesia showed that only morphine produced clinically relevant reductions in postoperative pain and analgesic consumption; fentanyl and sufentanil had a minor effect only. The incidence of pruritus was high (43%) but similar to morphine, fentanyl, and sufentanil. However, nausea and vomiting were less frequent with the lipophilic opioids than with morphine. The authors recommend morphine 0.1 mg as the drug and dose of choice.[72]

Adverse Effects of Intraspinal Opioids

Pruritus

Although systemic administration of opioids is known to cause pruritus, it is most frequent after spinal administration of opioids. It may be generalized but is more likely to be localized to the face, neck, or upper thorax. Pruritus usually occurs within a few hours of injection, may be higher when the i.t. route is used, and is lower following subsequent doses. Pruritus has been associated with almost all opioids. Pregnant patients seem more at risk irrespective of the opioid administered; this may be

attributable to interaction of estrogen with opioid receptors. The reported incidence of itching following intraspinal opioids is quite variable. Figures ranging from 0% to 100% have been published in the literature. The probable reason is that if not asked specifically, the majority of patients do not complain about this complication because of its mild nature.

A systematic review of 22 randomized trials of pharmacologic control of opioid-induced pruritus showed an average of 60% of patients had some itching. With epidural and i.t. morphine, there was no evidence that the dose made any difference. Other opioids represented the same range of risk although the data were limited. The authors concluded that pruritus caused by opioid analgesia happens frequently, independent of the opioid used, the route of administration, or the dose. They also concluded that naloxone, naltrexone, nalbuphine, and droperidol were efficacious for opioid-induced pruritus; however, minimal effective doses were unclear. There was little data on the efficacy of interventions for the treatment of established pruritus. None of the other tested drugs, nalmefene, epinephrine, propofol, clonidine, hydroxyzine, or prednisolone, showed any worthwhile benefit.[78]

The systematic review demonstrated that there is "a lack of valid data on the efficacy of interventions for the treatment of established pruritus."[78] This conclusion agrees with an excellent review of the literature by Waxler et al.[79]

Urinary Retention

Bladder overdistention induced by retention is associated with stretching, which may lead to dysfunction of the detrusor muscle. Urinary retention induced by i.t. and epidural opioids is likely related to interaction with opioid receptors located in the sacral spinal cord. This interaction promotes inhibition of sacral parasympathetic nervous system outflow, which causes detrusor muscle relaxation and an increase in maximal bladder capacity leading to urinary retention.[80] The reported incidence of urinary retention following epidural or i.t. opioids varies considerably.[80,81] It is difficult to establish the incidence of urinary retention because the majority of patients who receive epidural or i.t. opioids are high-risk patients undergoing major surgery who are usually catheterized. The incidence is not related to the dose of opioid administered. Urinary retention following i.t. and epidural opioids is much more common than after i.v. or i.m. administration of equivalent doses of opioid.[49,80-84]

Lipophilic opioids may have a more favorable profile. Studies with i.t. fentanyl in volunteers[85] and in patients undergoing knee surgery[86] did not show any significant increase in time to urination. Intrathecal sufentanil alone for extracorporeal shock wave lithotripsy was associated with shorter time to voluntary micturition as compared with spinal lidocaine.[87] It should be noted that i.t. epinephrine increases the time to voluntary micturition.[88] Thus, i.t. lipophilic opioids may be the preferred spinal anesthetic adjuvants for outpatient procedures.[89] If patients are unable to void 6 hours after surgery and naloxone is ineffective, a single in-and-out catheterization is indicated to prevent myogenic bladder damage because of prolonged overdistension.

Nausea and Vomiting

The incidence of nausea and vomiting following i.t. and epidural opioids is approximately 30%.[90] Although nausea and vomiting are generally considered a side effect of opioid administration, intraspinal opioids may actually protect against intraoperative nausea and vomiting (IONV).[91] In patients undergoing caesarean section under regional anesthesia, IONV is quite frequent, especially during uterus exteriorization and peritoneal closure. Several recent studies have shown that the risk of IONV can be reduced when i.t. fentanyl is added to spinal LA for caesarean delivery.[91-94] Indeed,

i.t. fentanyl has been shown to be superior to i.v. ondansetron in preventing nausea and vomiting during caesarean delivery.[95]

Incidence of Respiratory Depression Following Intraspinal Opioids

This is the adverse effect of most concern and therefore most widely studied. The true incidence of clinically significant respiratory depression is not known. Because of the rarity of late-onset respiratory depression, small sample sizes and invasive respiratory measurement techniques, the majority of prospective studies of epidural morphine have not detected clinically significant respiratory depression.[96]

It is interesting to note that after more than 25 years of clinical use and hundreds of papers, there is no clear definition of the most serious effect of spinal opioid administration. A review of the literature, which included 209 studies, showed that the term "respiratory depression" has not been clearly defined for the use of i.t. morphine for postoperative analgesia. Although defining bradypnea is better than having no definition, this is inadequate.[97] Several anecdotal reports of late-onset respiratory depression and "near misses" have been published. The results from large surveys involving thousands of patients suggest that the risk of late-onset respiratory depression following epidural morphine is less than 1%; this can be reduced further if certain risk factors are avoided. The risk of respiratory depression following other opioids may or may not be less; current data are inconclusive.

The quoted incidence of respiratory depression when epidural analgesia is supervised by an APS is no higher than the incidence of respiratory depression seen with other forms of opioid analgesia.[53] Regular monitoring of respiratory rate and, more importantly, the level of consciousness seems to be adequate to detect respiratory depression, and is indicated for up to 12 hours after a bolus injection of morphine and for the entire duration of a continuous infusion containing any opioid. The literature review by Werner et al.[5] showed that the incidence of serious postoperative opioid-induced respiratory depression requiring the administration of naloxone depended on the analgesic modality and was 0%–1.7% during fixed-rate morphine infusion (two studies), 0.1%–2.2% during PCA (11 studies), 0.1%–1.0% with spinal infusions of opioids (seven studies), and 0%–0.5% with a mixture of LAs and opioids (three studies).

Available data would suggest that the overall risk of severe respiratory depression from therapeutic doses of opioids is similar (<1%) regardless of the route of administration[53,98–105] (Tables 16-2 and 16-3); therefore, all postoperative patients receiving opioid analgesia, irrespective of route, merit diligent observation for respiratory depression.

TABLE 16-2. Incidence of Respiratory Depression Following Epidural Opioids

Total no. of patients	Respiratory depression (no. of patients)	Risk of respiratory depression (%)	Reference
6,000–9,000*	23	0.25–0.4	100
1,085*	10	0.9	101
14,000*	13	0.09	102
4,880*	12	0.25	103
1,106*	2	0.2	104
2,378	19	0.13	105
49,183†	45	0.09	53

*Morphine.
†Morphine (n = 33), fentanyl (n = 4), oxycodone (n = 4), diamorphine (n = 4).

TABLE 16-3. Incidence of respiratory depression on surgical wards after epidural LA–opioid combination for postoperative analgesia*

Study no.	Total no. of patients	Respiratory depression (no. of patients)	Risk of respiratory depression (%)	Opioid	Reference
1	4,227	3	0.07	Morphine	20
2	1,014	4	0.4	Fentanyl	22
3	614	3	0.49	Sufentanil	61
4	2,000	3	0.15	Morphine	21
5	1,062	4	0.32	Fentanyl	13
6	1,030†	?	0.2	Fentanyl	58
7	5,602†	0	0	Sufentanil	11
8	1,057†	2	0.19‡	Fentanyl	59

*LA in all studies was bupivacaine. Brodner et al. (study 7) also used ropivacaine.
†PCEA technique.
‡Additionally, one patient was unarousable.

Intraspinal Opioids and Monitoring Routines

It is clear that respiratory depression following intraspinal opioids is unpredictable and may be associated with any opioid (Tables 16-2 and 16-3). It should be emphasized that respiratory rate alone is inadequate to establish the presence or lack of respiratory depression.[106] Monitoring of level of consciousness is important because increasing sedation is associated with advancing respiratory depression.[52] Data from more than 20,000 patients from the Swedish surveys and from other large studies show that respiratory depression, if it occurs, will manifest itself within 12 hours after injection of morphine.[50,102,107] At our institution, the 12-hour observation routine has been used since 1980 for thousands of patients without any major problems. For lipophilic opioids, the observation period can be reduced, to perhaps 4–6 hours after fentanyl and sufentanil.

Current evidence suggests that most patients can be safely monitored on regular wards if (a) personnel are trained and preprinted guidelines for potential emergencies are provided, (b) patient selection and opioid dosing is appropriate, and (c) respiratory rate and level of sedation are checked every hour. Since 1992, these guidelines have been accepted by the Swedish Society of Anesthesiology and Intensive Care (SFAI). European Society of Regional Anaesthesia (ESRA)[108] has recommended similar guidelines. It should be noted that monitoring routines vary among countries and also among institutions in the same country.[105,109] The efficacy and safety of spinal opioids on surgical wards is best assured when these analgesic techniques are used under the supervision of organized APSs.[6,11]

Complications of Regional Techniques for Pain Management after Ambulatory Surgery

With the advance of catheter and disposable pump technologies, it is now possible not only to provide superior analgesia with continuous peripheral nerve blocks but also to send patients home with an ambulatory perineural block anesthetic infusion. Patients have been sent home with perineural, intraarticular, surgical wounds, and periosseous (e.g., supraperiosteal and subalveolar) LA infusions.[110] There are now studies showing the efficacy and safety of ambulatory continuous interscalene blocks,[111,112] infraclavicular blocks,[113] axillary blocks,[114] sciatic nerve blocks,[115–117] femoral nerve blocks,[118] psoas compartment blocks,[119] and paravertebral blocks.[120]

Continuing regional anesthesia in the home environment has been demonstrated to reduce analgesic consumption and reduce sleep disturbance. Disposable pumps are now available that use continuous infusions at a variety of preset rates, with or without patient-controlled boluses. Catheter removal may be successfully performed by the patients, by another healthcare provider, or by the patient caregiver with telephone supervision.

However, perineural techniques have a potential for significant complications such as nerve injury,[121] catheter migration leading to local anesthetic toxicity,[122] and unintentional spread of blockade epidurally or i.t.[123] Although this author was the first to report the use of perineural (and incisional and intraarticular) catheter analgesia at home,[110,114] and the perineural catheter technique is still used at our institution, our preference is for incisional and intraarticular catheter techniques because of their simplicity and safety, which are the two most important prerequisites for such techniques at home. Another reason for restrictive use of ambulatory perineural catheters is that in Sweden (and in most countries outside the United States) extensive joint surgery, which is one of the most important indications for perineural catheter techniques, is not an ambulatory procedure at present. Different infiltration techniques have been shown to be pain reducing and opioid sparing after cholecystectomy,[124] inguinal hernia repair,[125] breast surgery,[126] gynecologic laparotomies,[127] orthopedic,[128] anorectal,[129] and cardiac surgery.[130]

The use of incisional and intraarticular LA drugs to treat postoperative pain is an attractive technique because of its simplicity, safety, and low cost. Administration of LA in the wound or joint has several advantages over perineural techniques for postoperative analgesia.[131] Continuous wound infiltration with a disposable infusion pump, with or without a patient-controlled bolus, may provide several days of analgesia. Although these techniques may not be as potent as continuous peripheral nerve blocks, they are credited with being safe and very simple to use. They can be easily combined with a single-injection peripheral nerve block.[131]

Discharge and Follow-up – Safety Considerations

The discharge and follow-up routines will depend on the type of block for surgery (CNB or peripheral nerve block) and also on whether a simple injection technique or a catheter technique is used. In most centers, the single injection technique is routine; however, catheter technique is being increasingly used to provide superior pain relief after surgical procedures that are associated with moderate to severe pain.

Discharge of the Patient with Blocked Extremity

Many anesthesiologists still consider discharge of patients with insensate extremities controversial. Theoretically, these patients with blocked extremities would be more predisposed to limb injury because of lack of protective pain reflexes and reduced proprioception. Patients undergoing upper limb surgery should be instructed to wear a sling at all times to protect the anesthetized limb, and not to drive.

LA Toxicity

LA toxicity is a potential complication when continuous perineural infusions are used. Although the majority of cases occur when large-volume boluses of local anesthetics are used during block placement, toxicity is still possible with continuous infusion at home. To minimize the risk of toxicity in the ambulatory and home settings, a long-acting local anesthetic with a good safety profile should be used. Low concentrations can provide motor-sensory differential blockade allowing patients to actively participate in their postoperative rehabilitation. Currently, ropivacaine seems to be the best choice. Careful catheter testing should be performed to avoid inadvertent vascular placement and consequent local anesthetic toxicity.[132]

Catheter Insertion Site Infection

The risk of infection is always possible with any percutaneous technique (see Chapter 19). Cuvillon and coworkers[133] demonstrated that the risk of infection of femoral nerve catheters is small, although bacterial colonization is common. They also demonstrated that 57% of 208 femoral catheters were most frequently colonized by *Staphylococcus epidermidis* (71%), *Enterococcus* (10%), and *Klebsiella* (4%). None of the patients demonstrated any clinical evidence of infection or abscess formation. Similarly, catheter tips colonized by bacteria were reported for intraarticular catheters without any signs of clinical infection.[134] Vintar et al.[135] isolated *S. epidermidis* on the tips of 3 of 38 intraarticular catheters; there were no signs of local inflammation, but one patient needed antibiotics to treat increased body temperature. The incidence of infection after arthroscopic surgery is generally very low: 0%–0.2%. Rosseland et al.[136] reported no infection in more than 150 patients treated with an intraarticular catheter. We have not seen any infection after subacromial catheters during the last 8 years.[110,114] Park et al.[137] did not report any infection in their study of intrabursal catheter technique for shoulder surgery. However, intraarticular catheter infection requiring antibiotic treatment has been reported in two patients.[138,139]

All continuous peripheral nerve catheters are at risk for infection. However, with careful attention to aseptic technique during catheter placement, this problem is infrequent in clinical practice. Patients should also be aware of signs and symptoms of infection and contact healthcare professionals immediately in this case.

Catheter Dislodgment

Although catheter dislodgment is a major concern, especially outside the hospital environment, this complication is very uncommon. Several techniques to secure perineural catheters have been reported including suturing, cutaneous sutures, retrograde subcutaneous tunneling, medical adhesive solutions, and 2-octyl cyanoacrylate glue. In addition, some sites are easier to secure catheters (e.g., infraclavicular), decreasing the probability of dislodgment.[132]

Catheter Migration

Migration of perineural catheters is also a potential problem that can lead to serious complications, such as LA toxicity from intravascular migration,[122] interpleural migration of interscalene catheter,[140] centroneuraxial spread from i.t. or epidural migration of lumbar plexus and interscalene catheters.[141,142]

Infusion Pump Problems

To determine the optimal device for safe delivery of LA at home, factors that need to be considered are flow-rate accuracy, infusion flexibility, and total LA volume requirement. In general, there are two types of pumps: single-use elastomeric and multiple-use electronic pumps. Although the nonelectronic elastomeric pumps are not as accurate or as flexible as electronic pumps, studies show that patients prefer simple devices that avoid the need for reprogramming or the problems caused by frequent alarms.[143] There is extensive experience with nonelectronic pumps providing safe and effective postoperative analgesia at home. Simplicity and safety are not mutually exclusive and the physician should ensure that the selected device provides the prescribed dose of LA within reasonable limits.

Organizational Issues of Catheter Techniques at Home

Patient education should begin during the preoperative visit. Audiovisual material and information brochures allow patients to be psychologically prepared for surgery under regional anesthesia and for pain and its management at home. All authors who

TABLE 16-4. Patient Instructions for Postoperative Patient-controlled Regional Analgesia at Home

Inform the patient about the technique and how the "balloon pump" works (oral and written information). Information should also include the following: • Instructions for removal of catheter at the end of treatment • Importance of good hygiene near the wound area • Information about signs of LA toxicity or infection • There should be 24-hour access to anesthesia services.
Provide the name and telephone (and beeper) number(s) of the physician to be contacted in case of LA toxicity symptoms or other problems. • Ask the patient to return follow-up data about technique, satisfaction/dissatisfaction in a self-addressed envelope. • Telephone follow-up on the day after surgery by a nurse or physician

have used ambulatory perineural and incisional catheters emphasize the importance of good organization as a prerequisite for the safe delivery of such analgesic techniques at home. However, there is no consensus on the requirements for such an organization. Some practitioners have patients remove their catheters at home at the conclusion of their infusion, whereas others prefer removing the catheters themselves. Some discharge patients with written instructions regarding catheter removal, and others give verbal instructions over the phone during removal. Some investigators have provided twice-daily home nursing visits, whereas others have relied on daily telephone contact.[144] Studies from the United States show that the organization for perineural catheters is quite elaborate and includes: physician availability at all times, twice-daily home nursing visits in addition to telephone calls, catheter removal by healthcare provider or by the patient's caretaker with instructions on the phone by the anesthesiologist.[145–147] Our organization with the use of incisional and intraarticular catheter techniques is quite simple and consists of verbal and written predischarge information about pump function and use of PCRA rescue analgesic medication, symptoms of LA toxicity, local hygiene, catheter removal, return of completed patient diary, and contact numbers in case of problems (Table 16-4). A nurse from our PACU calls the patient the day after surgery to confirm the proper functioning of the technique. Patient selection is important and before discharge the patients are expected to demonstrate that they have understood the technique by using the pump in the presence of a PACU nurse. Our relatively simple approach is supported by the findings of a recent United States study, which surveyed the use of ambulatory catheter techniques at home. The follow-up survey of patients who had undergone ambulatory perineural infusion showed that 98% of respondents reported feeling "safe" with infusion and felt comfortable removing their catheter at home.[144]

Conclusion

Sending patients home with perineural, incisional, and intraarticular catheters is a new and evolving area of postoperative pain management. Although no large-scale study of possible problems has been published, the experiences of several centers that routinely use these techniques have not revealed any major complications. Current evidence suggests that these techniques are effective, feasible, and safe in the home environment if appropriate patient selection routines and organization for follow-up are in place. Understandably, follow-up routines are more elaborate for perineural techniques. Further studies are necessary to establish indications for incisional and intraarticular techniques as part of balanced analgesia concept and save the potentially more risky perineural techniques for the remaining patients. Outcome and risk studies are also necessary.

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