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Regional anaesthesia and postoperative analgesia techniques for spine surgery – a review

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Abstract

The use of regional anaesthesia techniques for intra-operative anaesthesia and postoperative analgesia remains very controversial for patients scheduled to undergo spinal interventions. Spine surgeries, especially the most extensive types, are mostly performed under general anaesthesia. This has to be explained by the position required during surgery, the preference of the surgeon and/or anaesthesiologist and lack of sufficient literature supporting locoregional anaesthesia. In addition, there is an increasing trend to prefer general anaesthesia for spinal surgery. Nevertheless, with respect to spine surgeries more than 80% of the actual literature on neuraxial blocks is dated less than 12 years. The present overview was focused in the first place on the feasibility of (loco) regional techniques to be used intra-operatively. These techniques are also of interest for postoperative analgesia, either with a single bolus injection of local anaesthetics, opioids and adjuvants, alone or in combination, in continuous or intermittent administration and requiring the presence of foreign material in the neighborhood of the surgical field. As all techniques described offered variable success rates, future research is mandatory to determine their superiority over general intra-operative anaesthesia and conventional pain therapy with paracetamol, NSAIDs, opioids used alone or in combination.

Keywords: anaesthesia, analgesia, regional, surgery, spine

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Introduction

The most commonly used technique to anaesthetize patients scheduled for thoracic or lumbar spine surgery is general anaesthesia. However, several benefits of regional anaesthesia (RA) over general anaesthesia (GA) have been suggested for spine surgery [1]. Nevertheless, it is rarely used due to lower acceptance by patients, the fear for failures requiring to turn the patient again on the back, the ability to easily extend the duration of an operation in case of general anaesthesia, and/or anaesthesiologist preference for general anaesthesia because of secure airway establishment prior to placement of the patient in the prone position [2].

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Spinal, epidural or even caudal approaches for postoperative analgesia may be initiated before, during or after surgery, or even extended if regional anaesthesia has been already part of the procedure, combined with general anaesthesia. During the last years alternative techniques have been tried in replacement or additional to conventional systemic analgesia.

When reviewing the literature, the formulation of straightforward conclusions was impaired by the variability in the extent of the surgical procedure (ranging from microdiscectomy to scoliosis fusion) and also the terminology of interventions used (such as spine deformity surgery, interbody fusion, dorsal rhizotomy, etc.). This variable terminology makes it difficult to search for studies with the classical key-words, and also the design of the study (retro- or prospective, case controlled, open label, dose finding), the different approaches, the drugs selected, combinations of them, different methods of administering substances, the time of initiation, the age of the patient groups and the selected outcome parameter [3]. A majority of studies has focused on postoperative analgesia rather than intra-operative application of regional anaesthesia.

At present only 4 reviews have been published including a rather limited number of studies depending on the type of surgery selected. Most of them discussed spinal or epidural studies intended for postoperative analgesia only.

The present overview was mainly focused on the actual literature with respect to intra- and postoperative regional techniques with local anaesthetics, opioids or other adjuvant substances.

Regional anaesthesia: specific advantages over general anaesthesia?

Procedure time may be shorter than in case of general anaesthesia mostly because of a shorter interval between anaesthetic induction and incision but also following wound closure as there is no need to await awakening or recovery from the neuromuscular block [4, 5]. The reduced blood loss during surgery under regional anaesthesia may also shorten the surgical time. A cleaner operative field may be explained by either spontaneous breathing causing lower intrathoracic pressure and less distention of the epidural veins or, otherwise, by the induction of hypotension and vasodilatation due to the sympathetic block, although haemodynamic stability was better maintained in patients under RA, possibly due to inhibited release of stress hormones intra-operatively [1, 6-13]. As patients might be operated in lateral or sitting position, this may also reduce the presence of blood in the operative field due to orthostatic drainage of blood. However, one author worried about possible orthostatic pressure upon veins and CSF (cerebrospinal fluid) which may enhance the risk of bleeding and dural tear in other positions than prone position [10].

Nevertheless, following spinal anaesthesia for back surgery, the incidence of postdural puncture headache seems to be extremely low. It is speculated that surgical bleeding in the area of the dural puncture site may function as a blood patch [7].

A reduction in thrombo-embolic complications has also been reported in patients who received a spinal anaesthetic for spinal surgery, most probably related to the modulation of the hypercoagulable state that occurs and persists after major surgery. Neuraxial anaesthesia, with local anaesthetics (LA) and opioids, has been shown to enhance fibrinolytic activity, reduce antithrombin III activity to normal levels and attenuate increases in postoperative platelet activity [6, 7].

In scoliosis fusion procedures where a wake-up test is requested, the use of RA may lower the requirements of narcotics and muscle relaxants, accelerating partial arousal.

Patients who have had spine surgery in regional anaesthesia may experience less postoperative nausea and vomiting (PONV). There are some studies where RA has been supplemented with intravenous propofol sedation having itself antiemetic properties. In addition, RA was associated with improved gastric emptying and led to decreased nausea and vomiting [4, 6-8].

Another benefit of regional anaesthesia is the ability of the patient to self position [3, 7, 8], thus avoiding neural damage of the innervations of the upper trunk or neurovascular compromise of the intra-orbital structures (eye, optic nerve, ophthalmic artery).

Although urinary retention is commonly considered to be a problem after central nerve blocks, others found the incidence to be similar among patients operated under GA or spinal anaesthesia (SA), but without intrathecal opioids, or even more frequent with GA [4, 6, 8].

In the postoperative phase, (loco) regional anaesthesia and/or analgesia may cause lower pain scores and/or narcotic requirement with additional benefit in the incidence of PONV [4, 11]. Initiation of a regional anaesthetic technique before the surgical incision may suggest a pre-emptive analgesic effect as well, although to confirm this studies are required comparing per- versus post-incisional initiation. Not infrequently the term 'pre-emptive' has been used although the local infiltration was given after incision, immediately after neural root exposure [14, 15]. Even more, a better effect than placebo described with infiltration of LA before incision, did not prove a 'pre-emptive' effect [16].

Apart from some exceptions, the choice of the anaesthetic or analgesic technique rarely resulted in faster food intake, and PACU or hospital discharge [17].

Not all reports are in favour of spinal or epidural anaesthesia. Contrary to the previous studies, the study of Sadrolsadat et al. [2] revealed that SA has no advantages over GA. They found that GA causes less intra-operative bleeding but also higher satisfactory conditions for the surgeon and the patient. In addition, propofol via TIVA in these operations may reduce the incidence of nausea and vomiting. However, hypertension was more frequent during the recovery from general anaesthesia which confirms other studies [6, 11].

When using epidural anaesthesia, which is more time-consuming and longer lasting than a single spinal dose, no difference were found in the procedure time or time of mobilization out of bed when compared with general anaesthesia [18].

Patients operated for spine surgery are supposed to stay in bed in the supine position for at least 24 hours or longer. The most embarrassing problem for these patients may be difficulty to void even enhanced by the use of opioids. Neuraxial techniques may further

affect the detrusor reflex or the urge to void. This may require placement of a temporary bladder catheter which itself may cause urinary infection.

Other reasons for the low enthusiasm in favor of regional analgesic techniques are the increased costs, a high failure rate due to catheter loss in up to 37% of cases, more side-effects (pruritus, urinary retention, sedation, respiratory depression, motor impairment); a shorter period of a better analgesia (sometime only at rest and not on mobilization) may be better than with conventional analgesia or PCA, while others found that the benefit occurred too late during the postoperative phase [19-25]. Surgeons may oppose the use of regional anaesthesia as they want to evaluate the neurological function of their patients during the postoperative phase. The presence of a haematoma may cause cauda equine symptoms mimicking the effects of neuraxial local anaesthetics.

Are all patients and surgeries suitable for RA?

Spine surgery may range from minimal invasive discectomy surgery to extended scoliosis fusion. Both an anterior or posterior approach is possible. As a consequence the type of anaesthesia will also depend on this. Besides a pure regional or general anaesthesia technique, combination of both is sometimes to be preferred especially in longer lasting procedures [12].

Despite possible advantages of RA over GA, there are, besides the well known absolute contra-indications, some contraindications to RA being specific for patients undergoing spine surgery. These include severe or multilevel spinal stenosis, near complete-total myelographic block or myelographic demonstration of arachnoiditis [1].

A pre-existing spinal stenosis may cause a cauda equine syndrome, when the available space is compromised by even a small haematoma or excessive amounts of local anaesthetics in the epidural space peri-operatively, also in patients operated for other conditions than spine surgery. The spinal stenosis is mostly diagnosed after the occurrence of the cauda equine symptoms. However, the surgery of the spine itself may partly solve this problem.

Previous spine surgery may compromise success of an otherwise facile anaesthetic block even more with epidural than spinal anaesthesia, because of the unreliability of the spread of the local anaesthetic.

GA would be a better choice for procedures lasting longer than 2 hours or procedures with a possibility of excessive blood loss such as multiple level laminectomies, extended spinal fusions and spine distraction procedures using rods or pedicle screws. A level of surgery higher than T_{10} should not be done under neuraxial anaesthesia because of the cardiac and respiratory impact [3].

When performing the surgery in the prone position the chest-knee position may be less tolerated especially in patients with respiratory compromise [26].

Obese patients with protuberant abdomens are also more likely to be candidates for GA, because their ability to breath in the prone position may be compromised. To avoid gastric regurgitation, difficult intubation or placental transfer of medication effects upon the foetus, pregnant patients may be excellent candidates for neuraxial techniques, but another than the prone position should be considered.

Intra-operative regional anaesthesia techniques

Spinal anaesthesia (SA), as the primary intra-operative anaesthetic technique, has been successfully used for lumbar disc surgery, single and double level laminectomies and lumbar spine fusions [1, 4-6, 8]. Epidural anaesthesia (EA) has also been used but to a lesser extent than SA because it is more time consuming, may result in less optimal spread of the LA, while many surgeons fear the presence of foreign material such as catheters in the operative field, even when placed at some distance, placed postoperatively and covered by antibiotics [10-13, 18]. When epidural anaesthesia is performed, it is usually part of a combined neuraxial-general technique. The use of combined spinal-epidural anaesthesia has been rarely reported, but has been found to be better than SA, with additional analgesic perspectives for the postoperative period [27].

When the sitting or lateral position is used for performing a single dose central nerve block, the patient may resume the supine position immediately after the removal of the needle to enable the block to settle. The patient is then log-rolled to the prone position and permitted to self-position his torso and head [6].

The surgical procedure can also be performed in the lateral or sitting position [10]. Unless for the prone position a special frame is used, an alternative position may be mandatory in pregnant patients, of whom it is well-known are at risk for developing a herniated disc sometimes with cauda equina symptoms, requiring emergency surgery [28]. A review of 10 cases revealed that 6 patients with spinal disease were operated before 33 weeks of pregnancy with maintenance of the foetus [29]. Otherwise spine surgery is sometimes delayed to be performed at the same time as the C-section of during the subsequent days.

Among all available local anaesthetics (LA) bupivacaine is most commonly used. According to Jellish

et al., it produces a denser sensory block and enables better control of sensory and motor blockade while having the least incidence of an incomplete block in comparison with tetracaine [6].

With respect to the choice between plain or hyperbaric solutions, the spread of a plain substance is less affected by patient position than when using hyperbaric LA. As a consequence, plain solutions may produce unreliable or unpredictable levels and quality of anaesthesia, as found by Jellish et al. [6]. Contrary to this, Tetzlaff et al. found that plain bupivacaine is superior to the hyperbaric substance in these procedures [30]. According to their study, hyperbaric bupivacaine had a faster onset for complete motor and sensory block, but these patients had greater degrees of hypotension with more interventions to treat heart rate and blood pressure changes and required more often LA wound infiltration [30].

The upper sensory level should be at T_{10} or higher to provide adequate surgical anaesthesia, but high levels of motor block are poorly tolerated in the prone position because of lack of abdominal muscle strength and the inability to breathe deeply against possibly increased abdominal pressure as the intercostals muscles may be paralyzed [6].

Finally, there may be some concern to use central nerve blocks in patients with spine pathology not only due to the need for multiple attempts or risk of failure due to anatomical changes, either pre-existing or induced by previous treatment. Tetzlaff et al. demonstrated that patients with spine problems may experience more than twice the frequency of paraesthesia when receiving an intrathecal injection or catheter placement [31].

Local and regional postoperative analgesia techniques

Sharma et al. made an extensive review in 2012 with respect to all possible treatment regimens for postoperative analgesia after spine surgery including systemic, spinal and epidural analgesia, but excluding wound infusion and other alternatives [32]. As mostly general anaesthesia is performed for spine surgery, the most commonly applied analgesic technique for the postoperative period consists of intermittent doses, alone or in combination of paracetamol, NSAIDs, anticonvulsants such as pregabalin, alpha-2 agonists (clonidine, dexmedetomidine), ketamine and supplemented with opioids [33, 34].

The review of Sharma et al. [32] revealed that most surgeries such as discectomy, laminectomies and scoliosis repair benefit from a neuraxial analgesia technique with some limitations for patients operated for multilevel spinal fusions. Some of them may have undergone previous surgery suffering failed back surgery or chronic pain.

For minor surgery such as microdiscectomy, placement of stimulating electrodes or tunneled catheters, systemic conventional medication may be sufficient whereas, for more extensive surgery such as laminectomy, surgery requiring osteosynthetic instrumentation with scoliosis fusion as the most extreme surgical technique may require considerably more than that. It should also be emphasized that many patients are already under pain therapy as they suffer acute or chronic pain some time before the day of surgery. As a consequence, the surgical intervention inducing superimposed pain may require more pain treatment than is used for their pre-existing discomfort.

A major advantage is that postoperative analgesia is more easily performed in a randomized double-blind design, as opposed to intra-operative anaesthesia. Injections can be given or catheters placed at any time before incision, during surgery, at pre-closure or even after surgery. This can be achieved by the anaesthetist or the cooperative surgeon.

Neuraxial catheters that had been placed for intra-operative anaesthesia can be used for postoperative analgesia. When this option is not feasible, they can be placed for postoperative analgesia only and introduced before, during (under direct vision by the surgeon) or after surgery. Mostly catheters are placed at some distance from the surgical site i.e. 5-10 cm more cephalad [35, 36]. Another alternative is a single dose injection before, during or after the intervention.

Epidural analgesia

Epidural analgesia for postoperative pain relief has been described as an effective and safe method. It has been used for all kinds of spine surgery such as microdiscectomy, laminectomy, major spinal surgery, with or without instrumentation and scoliosis correction. A majority of studies, both retro- and prospective, has found benefits in terms of lower pain scores, less opioid rescue and enhanced satisfaction following neuraxial analgesia [37, 38]. A meta-analysis of 4 studies on scoliosis correction in adolescents by Taenzer and Clark (2010), with special reference to epidural analgesia after scoliosis surgery, revealed that pain scores were higher up to 72 h in those not having been treated with an epidural [39].

Despite encouraging reports, others found that differences in pain relief occurred as from 12 hours only, or was delayed to even days after surgery [20, 22]. A limited duration of analgesia should be expected when using substances in single dose application. Some authors found that epidural administration caused too many side-effects while more patients suffered from pain due to failure of the epidural modality and/or

catheter loss, while costs were significantly higher than with systemic analgesia [19, 40, 41]. Some surgeons will refuse the placement of permanent catheters, in or nearby their surgical field. Nevertheless the number of infections or neurological damage is extremely low despite growing experience with neuraxial techniques for this surgery. Finally, the later the start of analgesia (some centers wait until full motor and sensory recovery) the less potential benefit of a pre-emptive effect which is better guaranteed with an intended intraoperative anaesthetic block. Some authors mentioned the term 'preemptive' indicating that analgesia is started before any surgical trauma is initiated although not infrequently the epidural was given or placed after the incision. Therefore, the term 'preventive' analgesia with the purpose to provide comfort for the patient at awakening should be a better word choice.

The use of two epidural catheters has been thought to be more effective than a single catheter after spinal instrumentation and fusion [42, 43]. Less side-effects, faster return of bowel function and higher patient satisfaction were also noticed. Klatt et al. found that in comparison with single placement, the double continuous epidural analgesia with a bupivacaine 0.1% and fentanyl 2 μg/ml infusion most effectively controls postoperative pain following spinal fusion surgery, but the single continuous epidural modality tended to cause the fewest side-effects (pruritus, constipation and nausea) when compared to the double catheter technique or PCA [44]. They, along with others, also concluded that it was perfectly possible to obtain an adequate postoperative neurological examination in the immediate postoperative period when using low-dose and-concentrations of local anaesthetics.

With respect to the epidural medications used for postoperative pain relief by the epidural route, the most commonly reported are either local anaesthetics [24, 36, 42-45], opioids (morphine or fentanyl analogues) [23, 35, 46] or a mixture of both [9, 19, 22, 37, 47]. These can be given as a single bolus dose, continuous infusion or patient controlled epidural analgesia (PCEA).

Less commonly used adjuvant substances, used either alone or in combination are clonidine [48-50], midazolam [51] and methylprednisolone [52]. Jellish et al. used spinal bupivacaine in combination with epidural clonidine 150-300 μg in patients undergoing lumbar laminectomy. They found that epidural clonidine enhanced the sensory blockade of bupivacaine and produced better haemodynamics postoperatively, while there was no difference in the incidence of intraoperative hypotension or bradycardia between the clonidine and the control group [49].

Longer lasting analgesia with morphine may also be provided epidurally by the administration of extended release formulations [53] or application of sponges soaked with the opioid and functioning as a slow-release modality [54, 55]. Analgesia may outlast the duration registered with the same dose injected as a bolus.

Also the caudal route may be a suitable approach for a single dose injection. Sekar et al. compared a single dose injection of bupivacaine with tramadol, which has a comparable lipid solubility as morphine, versus saline and found it a simple, safe and effective alternative [16]. Children and adolescents operated for scoliosis fusion may be good candidates for such an approach as it is at a significant distance from the operative field. Our department has some experience with the caudal combination of 2-3 mg morphine and 30 μg clonidine, given before incision.

Intrathecal analgesia

A single intrathecal injection for postoperative pain relief given at any possible moment is also feasible and mostly restricted to an opioid such as morphine or a shorter acting fentanyl analogue [21, 56-59].

Morphine is the most reported opioid in this setting. Doses are extremely variable with a sometimes 10 fold range. Although for C-section the recommended intrathecal dose is 100 μg to treat both the somatic and visceral components, the dose recommended for spine surgery which is somatic are situated between 200 and 400 μg with doses ranging between 2-20 μg/kg for children and adolescents.

Milbrandt et al. found that continuous epidural infusion, compared with a single preoperative intrathecal morphine injection for posterior spinal fusion surgery, controls pain for the longest period of time and allows for a quicker return to solid food intake. However, a single preoperative intrathecal morphine injection controls the pain equally for the first 24 hours with less pruritus and with less adverse events. Both methods gave lower postoperative pain scores compared to PCA alone [57].

A case report has described the successful application of continuous spinal analgesia with a bupivacaine, fentanyl and morphine mixture [60]. Continuous spinal analgesia seems a bridge too far at the present time.

For more rostral types of surgery, interpleural and paravertebral techniques have been described, the former being of possible interest in case of anterior approaches [61, 62].

Local infiltration techniques

Also more locally restricted approaches are gaining interest when treating post-spinal surgery pain.

Instillation of the affected nerve roots by the surgeon before wound closure may represent an excellent alternative, being superior to at-closure infiltration [63]. Although wound infiltration can be started by the

anaesthesiologist before the incision, most reports described local instillation by the surgeon immediately after exposure of the affected nerve root i.e. after skin incision or the more superficial layers before closure [14, 15, 52, 64, 65]. It was also shown that the exact depth of the wound infiltration catheter position is not as important as previously anticipated [65].

An argument in favour of root infiltration may be the need for lower local anaesthetic doses than infiltration of the more extended skin and subcutaneous tissue. However, instillation with 200 mg ropivacaine followed by 10 mg/h was found to be more effective than systemic analgesia while plasma concentrations remained below toxic levels [66].

Reynolds et al. found that continuous infusion with local anaesthetics reduces postoperative morphine requirements with up to 0.5 mg/kg despite concomitant intrathecal morphine [67].

Very rarely, other substances than local anaesthetics are used for wound instillation. A single dose wound injection of levobupivacaine and tramadol 2 mg/kg (although a possible peripheral effect is highly debatable) was significantly better after discectomy than when injecting both substances alone, while none of the patients required additional pethidine [68].

Another reason why some centers may prefer wound infiltration or catheters over neuraxial catheters may be some fear that the epidural space and/or dura may be damaged during the surgery affecting the optimal spread of the local anaesthetic. However, Lavelle et al. did not find any arguments for avoiding epidural analgesia even in violated epidural spaces [69].

For percutaneous endoscopic lumbar discectomy also a lidocaine patch has been used successfully [70].

Alternatives, other than conventional pain therapy

Alhough they are not new techniques, intra-operative lidocaine infusion [71], TENS [72, 73] and acupressure [74] have also been reported to improve intra-operative comfort and satisfaction and, though not the scope of all studies, reduced postoperative pain scores and opioid consumption [71].

In **conclusion**, RA can be an excellent choice during and after spine surgery. It has specific advantages over GA but the failure rate may be extremely variable. Proper selection of surgeon, patient and procedure is imperative. Further studies are required to enhance the success rate of neuraxial approaches and the future of newer alternative techniques. Based on the limited number of studies, a conclusion cannot be reached which technique i.e. epidural, spinal or wound approaches should be preferred.

Conflict of interest

Nothing to declare

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Anestezia regională şi tehnicile de analgezie postoperatorie în chirurgia spinală – o actualizare

Rezumat

Utilizarea tehnicilor de anestezie regională în vederea obținerii anesteziei chirurgicale sau a analgeziei postoperatorii, în cazul pacienților supuşi intervențiilor la nivelul coloanei vertebrale, rămâne şi în prezent un subiect extrem de controversat. Chirurgia coloanei se desfăşoară în continuare, mai ales în cazul intervențiilor majore, sub anestezie generală. Acest fapt este explicat prin poziționarea specială a pacientului, preferința chirurgului şi anestezistului, şi de lipsa literaturii care să susțină suficient tehnicile loco-regionale. În plus, există o tendință actuală de a prefera anestezia generală în chirurgia vertebro-medulară. În ceea ce priveşte chirurgia coloanei, peste 80% din informațiile din literatură referitoare la blocurile neuraxiale datează de peste 12 ani. Această actualizare s-a concentrat în primul rând asupra aplicabilității tehnicilor loco-regionale în perioada intraoperatorie. Aceste tehnici sunt însă de interes şi pentru analgezia postoperatorie fie sub forma lor simplă de bolus cu anestezic local, opioid sau adjuvant, fie în administrare continuă sau intermitentă, necesitând în acest caz prezența unui material străin în proximitatea câmpului operator. Ca toate tehnicile descrise, acestea oferă rate de succes variabile, iar cercetări viitoare sunt necesare pentru a demonstra superioritatea tehnicilor regionale în raport cu anestezia generală sau cu terapia analgezică postoperatorie convențională cu paracetamol, antiinflamatoare nesteroidiene, opioide utilizate izolat sau în asociere.

Cuvinte cheie: anestezie, analgezie, regională, chirurgie, coloană