

Regional Analgesia Techniques for Spine Surgery: A Review with Special Reference to Scoliosis Fusion

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Abstract

The use of regional analgesia techniques for postoperative analgesia in spine surgery is less frequently used in comparison with conventional oral and parenteral treatment. This may be explained by the fact that surgery is mostly performed under general anesthesia. Although objections of the surgeon are comprehensible, there is a growing number of studies using regional techniques for the treatment of pain after this surgery.

When postoperative analgesia is the focus then regional techniques can be initiated at any time-point of the procedure while all ages and types of surgery, even extensive scoliosis fusion may benefit from it. The present overview will focus on the feasibility of (loco)regional techniques to be used for postoperative analgesia, medications used alone or in combination, as a single bolus or through persistent catheters and with special attention to pain relief following scoliosis repair.

In general neuraxial techniques offer lower pain scores and/or less need for opioid rescue in comparison with systemic conventional analgesia although much less benefit may be noticed in patients operated for spinal fusion than for disc surgery, laminectomy and adolescent scoliosis correction. The actual literature provides little evidence with respect to the best timing of initiation, the best route nor the best dose in relationship to the type of surgery. Besides neuraxial techniques several alternatives have found their way in this type of intervention. As all techniques described offered variable success rates, future research is mandatory to determine their superiority over general anesthesia and conventional pain therapy modalities.

Keywords: Anesthesia; Analgesia; Regional; Surgery; Spine

Introduction

The most commonly used technique to anesthetize patients scheduled for thoracic or lumbar spine surgery is general anesthesia followed by conventional pain therapy. Despite possible theoretical benefits of a regional technique for postoperative analgesia, it is rarely used due to lower acceptance by patients, surgeons and anesthetists. When not being part of an intra-operative anesthetic technique, performing an additional regional block may cause time-loss, while blocks may be performed in more difficult, other than the classical positions.

Although there is the actual trend to abandon central nerve blocks there is a growing number of studies that have evaluated all kinds of regional techniques. Nevertheless it remains surprising that of the more than 75 articles found less than 40% have been published in anesthesia journals while more than 80% were published since the year 2000.

The most frequently local and loco regional techniques described to improve postoperative analgesia in spine surgery are intrathecal, epidural single dose or continuous techniques or local infiltrations or wound catheters. This may be initiated before, during or after surgery or extended if regional anesthesia was already part of the procedure, even if combined with general anesthesia.

When reviewing the literature, making straightforward conclusions is disabled by the variability in the extent and definition of the surgical type (microdiscectomy, disc surgery, laminectomy, spinal fusion, spine deformity surgery, scoliosis correction and studies with mixed population), the design of the study (retro- or prospective, randomized, case controlled), 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. In most studies the aim was to compare differences in pain scores and/or the consumption of analgesic substances and/or the occurrence of side-effects.

Although regional techniques have been described since the beginning of the 90's and few even earlier, the present overview will mainly focus on the literature of the present century with respect to postoperative regional techniques.

Specific Concerns of Regional Techniques

When performing a neuraxial block before induction of anesthesia technical difficulty may be encountered. When initiated later on, patients may be asleep and positioning of the patient may be different from the one the anesthetist is most familiar with, which may cause technical problems and/or unnoticed neural damage. Starting the technique after incision will preclude a 'pre-emptive' benefit.

A reduction in thrombo-embolic complications may ensue in patients treated with a neuraxial analgesic technique, most probably related to either faster mobilization or the modulation of the hypercoagulable state that occurs and persists after major surgery. This effect is actually overwhelmed by the common use of prophylactic low-molecular weight heparins which may signify an additional issue with respect to timing of puncturing, catheter placement and removal.

Although urinary retention is commonly considered to be a problem after central nerve blocks due to mainly local anesthetic and/or opioid use, also systemic opioids will cause voiding difficulty, delayed

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gastric emptying, nausea and vomiting. Some patients will receive an indwelling catheter as from the start of surgery depending of the extent of the intervention. When initiating a neuraxial technique either as the main intra-operative technique or for analgesia purposes before awakening, may need patients to stay longer time in the recovery room because of hypotension or delayed recovery of the block.

Previous spine surgery but also the surgery for which neuraxial analgesia has been scheduled may compromise optimal functioning of medication and catheters during the postoperative period because of the unreliability of the spread of the local anesthetic. However, it has been shown that the failure rate is not increased and therefore mostly a theoretical concern [1,2].

In scoliosis fusion procedures wake-up of the patient is requested in some hospitals by the surgeon after placement of the rods. The use of RA, provided that a possible motor block would have faded or no local anesthetics were used, in combination with general anesthesia may lower the requirements of narcotics and more particularly muscle relaxants, accelerating partial arousal and muscular function sufficient to obey commands.

Many surgeons will refuse invasive analgesia techniques regardless of the type of surgery mostly because of fear for infection. Scoliosis may result from neuromuscular disease such as Duchenne's dystrophy with immunological or physical compromise further enhancing the risk of infection. Secondly the sensory block with or without motor block will prevent the observation of neural damage caused by the surgery or development of a hematoma.

Other reasons for low enthusiasm in favor of regional analgesic techniques are the increased costs, more catheter loss, more disturbing side-effects, too short the period during which analgesia may be better than with conventional analgesia or PCIA.

Experience with Local and Regional Analgesia Techniques

A search was done in PubMed and Embase. Initially and for reasons of completeness all reports were considered including previous reviews, comparative trials, cohort studies and exceptionally some case reports. Double-blind randomized trials are rather rare in this surgery. For the part focusing on scoliosis fusion only comparative studies were considered.

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 anesthesia will also depend on this.

The use of a pure intra-operative regional technique, even administered as a single dose, may offer benefits in terms of postoperative analgesia, mostly by lower pain scores and/or reduced need for opioid rescue. This has been described in studies comparing either spinal or epidural anesthesia with general intubation narcosis [3-11] but this will not be further highlighted below. As it is difficult to make a distinction among studies that have described the combination of general anesthesia or propofol sedation combined with either epidural 'anesthesia' or 'analgesia', these studies will be discussed under the same denominator as all studies that have combined general anesthesia with a neuraxial technique intended for postoperative analgesia purposes.

Besides the well-known absolute contra-indications, some contraindications to RA technique may be specific for patients undergoing spine surgery. These include severe or multilevel spinal

stenosis, near complete-total myelographic block or myelographic demonstration of arachnoiditis [7]. Especially with pre-existing spinal stenosis, as far as known in advance, cauda equine may occur when further increasing the compression of the spinal cord by extensive volumes of medication given epidurally.

Previous reviews

Four reviews have been published during the last decade with respect to analgesic treatment options after spine surgery. The first by Tobias et al focused only on analgesia in pediatric spine surgery and the possible benefit of spinal or epidural analgesia [12]. For several reasons the results of that review were inconclusive with respect to the superiority in terms of analgesia but found less blood loss and quicker return of bowel function with a regional technique.

Taenzer and Clark [13] reviewed 4 studies on the effect of epidural analgesia after scoliosis fusion.

Also the review of Borgeat and Blumenthal in 2008 focused on analgesia after scoliosis fusion [14].

Actually at least 10 studies have been published meanwhile comparing neuraxial analgesia with conventional treatment.

Sharma et al made an extensive review in 2012 with respect to systemic, epidural and spinal analgesia for postoperative analgesia after all kinds of spine surgery [15]. As mostly general anesthesia 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 and opioids. Recently also newer substances have joined the armamentarium such as pregabalin, dexmedetomidine, ketamine, [16-19]. As systemic treatment is not the aim of the present review, this will not be further discussed.

General findings

For minor surgery such as microdiscectomy, placement of stimulating electrodes or tunneled catheters systemic analgesia may indeed 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.

Based on the review of Sharma et al. [15], extended with other and more recent reports, it may be stated that in general discectomy, laminectomy and scoliosis correction are doing better in terms of pain scores at 24 and 48 hours and less analgesic rescue. Patients operated for spinal fusion are more suitable to result in non-significant differences when compared with systemic analgesia. Less than 40% of the studies found poor, if ever, benefit with either intrathecal or epidural modalities. A plausible explanation may be that many patients scheduled for instrumented spinal fusion, more than discectomy or scoliosis surgery already underwent previous discectomy or laminectomy and/or are sometimes receiving longstanding pain therapy as they suffer chronic pain some time before the day of surgery. As a consequence the surgical intervention, inducing superimposed pain, may require more pain treatment than used for their pre-existing discomfort. This may explain why regional techniques may not do better or equally poor than systemic analgesia.

Neuraxial catheters being placed for intra-operative anesthesia can be used for postoperative analgesia. When this option is not feasible single injections can be given or catheters placed for postoperative analgesia purposes only and introduced before, during but before closure (neuraxial, wound or root catheters, under direct vision by

the surgeon) or after the surgery. Mostly catheters are placed at some distance i.e. 5-10 cm from the surgical site.

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. Catheters have been placed at all moments during the procedure. In comparative studies with conventional treatment the epidural regimen (bolus, continuous infusion or PCEA) consisted mostly of the local anesthetics bupivacaine or ropivacaine 0.0625-0.3% with or without an opioid [20-41] or an opioid alone [42-50]. Morphine is the most frequent selected opioid followed by fentanyl, sufentanil, hydromorphone, buprenorphine and tramadol.

Less commonly used adjuvant substances, used either alone or in combination are clonidine [51-53], methylprednisolone [54,55] and midazolam [56]. Bonhomme et al. found the combination of clonidine with morphine to be superior to a combination with bupivacaine [51]. 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 hemodynamics postoperatively while there was no difference in the incidence of intra-operative hypotension or bradycardia between the clonidine and the control group [52].

A majority of studies has found benefits in terms of lower pain scores and/or less opioid rescue following epidural analgesia up to 72 h.

Other advantages were less side-effects such as nausea/vomiting [9,34,41,53,55], faster return of bowel function and oral intake [23,48,54], faster ambulation [52], enhanced patient satisfaction and in a few studies faster hospital discharge [21].

Despite encouraging reports others were less convinced of the superiority of the epidural. Some found that pain relief was too short [39,50] which is not surprising with one injection of either 10 mL of ropivacaine 0.1% or 100 µg of fentanyl. A limited duration of analgesia should be expected when using substances in single dose application. Others found that differences in pain relief occurred only after 12 hours, even days after surgery [35,37]. Some authors found that due to the frequent side-effects the epidural route could not be recommended as first line treatment for postoperative analgesia after spine surgery [24,35,47], while more patients suffered paresthesia with placement of the catheter [25-27]. Failure of the epidural modality, need for temporarily or permanent discontinuation of epidural treatment and/or catheter loss while costing significantly more than systemic analgesia were additional reasons for less enthusiasm in certain studies [20,29,34].

Longer lasting analgesia with morphine may also be provided epidurally by the administration of extended release formulations [57], application of sponges soaked with or compounds containing morphine (1-5 mg) or meperidine and functioning as a slow-release modality [58-62]. Analgesia may outlast the duration registered with the same dose injected as a bolus. Mastronardi et al. experimenting with Vaseline-sterile-oil-morphine or barrier gel morphine-Adcon-L compound found less development of epidural fibrosis and faster return to normal function [61,62].

With respect to scoliosis surgery most comparative studies found epidural analgesia to be extremely beneficial [21,29,34,36,63-67]. Only three studies [21,23,26] found no differences in pain scores although

Van Boerum et al. noticed faster bowel recovery and hospital discharge times [21]. Especially for scoliosis fusion the use of two epidural catheters has been thought to be more effective than a single catheter after extensive spinal instrumentation and fusion [63-67]. Before closure one catheter is introduced above the cranial end of the incision aiming at placing the catheter tip between T1-T4 while the second one at the lower end of the incision to be directed caudally with the tip between the lower thoracic dermatomes if possible and L4. Initiation of catheter use is mostly delayed until a normal postoperative neurological status is recorded. Also for anterior surgical approaches a double catheter modality, introduced transforaminally seems to be more effective than intravenous morphine [66]. Less side-effects, faster return of bowel function and higher patient satisfaction were also noticed. Klatt et al. found that in comparison with single catheter 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 PCIA [67]. They, along with others, also concluded that it was perfectly possible to obtain an adequate postoperative neurological examination in the immediate postoperative period even in complicated cases where an accurate and specific examination is necessary.

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 50 mg, which has comparable lipid solubility as morphine, versus saline and found it a simple, safe and effective alternative [28].

Intrathecal analgesia

A single intrathecal injection for postoperative pain relief given at any possible moment is also possible and mostly restricted to an opioid such as morphine or to a lesser extent the shorter acting fentanyl and sufentanil or combinations of them with morphine to obtain both a faster onset and longer duration of analgesia [68-84].

In comparison with epidural treatment the benefits in terms of lower pain scores and/or less rescue analgesic consumption are less pronounced as in less than 50% of the studies the intrathecal treatment group did better than the placebo.

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 PCIA alone [80].

Among other substances that have been used intrathecally, in one report betamethasone was administered intrathecally while another report mentions the use of 100 µg neostigmine [85,86].

A case report has described the successful application of continuous spinal analgesia with a bupivacaine, fentanyl and morphine mixture [87].

With respect to intrathecal use of morphine the doses range between 100 µg up to 1 mg or between 2 and 20 µg/kg but based on most studies the optimal dose, depending on the extent of surgery may be situated and 0.2-0.4 mg or 10-14 µg/kg. Tripi et al found that with a dose range of 9-19 µg/kg (average 14 µg/kg) less respiratory depression occurred and less children undergoing scoliosis surgery need to be admitted for

this at the Pediatric Intensive Care Unit [79]. Regarding sufentanil and fentanyl the experience is far too limited to suggest optimal doses.

Although pain after spine surgery is in fact of somatic origin, the doses of morphine reported are higher than for Cesarean section which causes both somatic and visceral pain. Due to the rather high doses of morphine used, a higher incidence of side-effects such as pruritus is not surprising [68,74,75].

Scoliosis fusion

Being the most invasive surgery this review intended to give special attention to studies focusing on epidural and intrathecal analgesia techniques. Table 1 contains all comparative studies that have been performed until today with respect to postoperative pain treatment after scoliosis fusion. Series reports without any comparison were not considered for inclusion.

Of the 16 neuraxial studies found, five were using intrathecal opioid treatment versus 10 for which epidural was selected with one study combining both routes. So, it was not possible to conclude which technique is the best in terms of analgesic quality as there is a lack of studies comparing both routes. In scoliosis repair only Milbrandt et al. compared intrathecal morphine with epidural analgesia a found the intrathecal route to offer the fastest onset while the epidural route provided analgesia of longer duration [80]. In another non-scoliotic study [76] placebo was compared with low-dose intrathecal morphine (0.1 mg), epidural morphine (2 mg) and epidural bupivacaine (30 mL, 0.25%) and confirmed the overall impression that side-effects seem to be more frequent with an intrathecal approach while epidural analgesia, mostly by catheter use, will also induce longer lasting analgesia than a single shot intrathecal bolus.

In conclusion for scoliosis fusion, a neuraxial technique offered in most studies, except for two reports, significant benefit in terms of either lower pain scores, less analgesic rescue, less side-effects such as PONV, ileus, blood loss or urinary retention.

Peripheral blocks and local infiltration techniques

For thoracic and cervical types of surgery interpleural and paravertebral techniques have been described with the former being of possible interest in case of anterior approaches [88,89].

Also more locally restricted approaches are gaining progress when treating post-spinal surgery analgesia.

Instillation of a local anesthetic before incision may be an excellent alternative, being superior to at-closure infiltration [90]. The authors used either bupivacaine alone or with methylprednisolone and demonstrated a preemptive effect in comparison with infiltration before closure.

Unfortunately most reports described local instillation after incision [54,91-94] immediately after exposure of the affected nerve root or the more superficial layers before closure, all of which, despite some authors have suggested [91,92], cannot be considered as 'pre-emptive' but rather 'preventive'.

Ross et al have used a continuous infusion in scoliosis surgery and found that the exact depth of the catheter position is not as important as previously anticipated [94].

An argument in favor of root infiltration may be the need for lower local anesthetic doses than infiltration of the more extended skin and subcutaneous tissue. However, instillation with 200 mg ropivacaine followed by 10 mg/hr was found to be more effective than systemic

| Author (year) | Design | Comparison | N° of pts | Analgesia with the regional technique | Other findings |
|---------------------------|-------------------------------|---|-----------|---|---|
| Goodarzi (1998) [84] | prospective | IT vs. narcotics | 80 | longer pain free | Less blood loss |
| Cassady (2000) [23] | RCT | TEA vs. PCA | 33 | ND | |
| Van Boerum (2000) [21] | retrospective | EA vs. PCA | 50 | ND | Solid intake and LOS: 0.5 day faster |
| Gall (2001) [73] | RCT | ITM: 0.2 and 5 µg/kg | 30 | Lower VAS, less opioid, mVAS equal | 5 µg /kg : less bleeding |
| O'Hara (2004) [26] | RCT/DB | EA vs. PCA | 31 | ND | ND |
| Sucato (2005) [29] | retrospective | EA vs. PCA | | Lower maximal VAS | >10% interruption or stop |
| Blumenthal (2005) [65] | RCT | EA (2 catheters) vs. IV | 38 | Lower rVAS and mVAS Less opioid rescue | Faster bowel recovery, less pruritus and PONV |
| Blumenthal (2006) [66] | RCT | | 30 | | |
| Eschertzhuber (2008) [77] | prospective randomized | IT (plac vs. LD vs. HD) | 46 | Lower VAS Less opioid rescue Day 1 | HD not better, less blood loss |
| Tripi (2008) [63] | prospective | ITM (plac vs. LD vs. HD) | 407 | Lower VAS with LD and HD | >20 µg/kg: more RD and PICU |
| Pham Dang (2008) [32] | RCT/DB | EPI Ropi vs. Bupi | 18 | Bupi : lower mVAS | |
| Milbrandt (2009) [80] | Retrospective cohort | ITM vs. EPI vs. PCA | 138 | Lower VAS Less opioid rescue | IT faster analgesia EA : longer analgesia |
| Gauger (2009) [34] | RCT | PCEA vs. PCA | 38 | Lower VAS Day 2 and 3 | 37% failure rate |
| Lavelle (2010) [1] | retrospective | EA vs. PCA | 55 | Lower VAS Day 1 | ES violation: equal analgesia |
| Ravish (2012) [81] | Retrospective case comparison | ITM+ EPI vs. PCA | 146 | Lower VAS Less opioid | Benefit during 5 Days Less UR and ileus |
| Klatt (2013) [67] | RCT | Single- vs. double catheter EA vs. PCA | 66 | Double catheter: lowest VAS, single=PCA | Single: less side-effects |

EPI: Epidural; IT: Intrathecal; ITM: Intrathecal Morphine; EA: Epidural Analgesia; AE: Adverse Events, TEA: Thoracic Epidural Analgesia; LOS: Length of Stay; PCA: Patient Controlled Analgesia; PICU: Pediatric Intensive Care Unit; rVAS: rest VAS; mVAS: mobile VAS; ES: Epidural Space; ND: Not Different; RCT: Randomized Controlled Trial; DB: Double-Blinded; LD: Low Dose; HD: High Dose

Table 1: Comparative studies in scoliosis fusion.

analgesia while plasma concentrations remained below toxic levels [95].

Reynolds et al found that continuous subcutaneous infusion with bupivacaine 0.25%, 2 mL/hr via two catheters reduces opioid requirements after scoliosis surgery with up to 0.5 mg/kg despite concomitant intrathecal morphine in both groups [96].

Very rarely other substances than local anesthetics are used for wound instillation. A single dose epidural injection of levobupivacaine and tramadol 2 mg/kg (although the peripheral effect and even the effect on the dorsal horn of this hydrophilic opioid are debatable) was significantly better than when injection both substances alone while none of the patients required additional pethidine [97].

For percutaneous endoscopic lumbar discectomy also a lidocaine patch has been used successfully [98].

Alternatives, other than conventional pain therapy

Although not new techniques, intra-operative lidocaine infusion [99], TENS [100] and acupressure [101,102] have also been reported to improve intra-operative comfort and satisfaction and reduce postoperative pain scores and opioid consumption. The finding that intravenous intraoperative lidocaine infusion offers better analgesic quality, functional rehabilitation and quality of life at 1 month after complex spine surgery than placebo does not warrant a change of practice yet.

In conclusion, neuraxial analgesia receives growing interest in the treatment of postsurgical pain relief after different spine interventions. In general, although a minority of studies disagrees, it offers superior analgesia in comparison with conventional systemic analgesia as evidenced, alone or in combination by either lower pain scores, less opioid rescue, less side-effects or other benefits. More comparative studies are needed to determine the future benefit and place of newer systemic substances with analgesic properties or alternative routes such as local wound or root infiltrations.

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