



Original article

Continuous paravertebral block as an analgesic method in thoracotomy

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A B S T R A C T

Introduction: Open thoracotomy is one of the surgical procedures that is still very painful in the postoperative period, which, in this type of surgery can have on respiratory function and subsequent recovery of the patient.

Patients and method: The aim of the study is to assess continuous paravertebral thoracic block as an analgesic technique in thoracotomy. A total of 139 patients undergoing pulmonary resection surgery by posterolateral thoracotomy received postoperative analgesia using a 1.5% lidocaine infusion (7-10 ml/h) through a thoracic paravertebral catheter for at least 48h. Pain intensity measured on the visual analogue scale (VAS) both at rest (passive VAS) and during stimulated cough (active VAS) was recorded at time of discharge from the Recovery Unit, and on the second, third and fourth day post-surgery. Postoperative complications and the need for analgesic rescue were studied.

Results: On discharge from recovery, 98.6% of the patients had mild pain (passive VAS <3), 1.4% had moderate pain (passive VAS 4-6) and none with severe pain (EVA >6); on the 2nd day post-surgery, 97.9% had mild pain, and 1.2% moderate pain; on the third day 98.6% had mild pain and 0.7% moderate pain; and on the 4th day 100% had mild pain. There were no complications arising from the analgesic technique.

Conclusions: Continuous thoracic paravertebral analgesia is effective and safe in controlling post-thoracotomy pain.

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Eficacia del bloqueo paravertebral continuo como método analgésico en la toracotomía

R E S U M E N

Introducción: La toracotomía abierta es uno de los procedimientos quirúrgicos con postoperatorio más doloroso, hecho que en este tipo de cirugía puede repercutir sobre la función respiratoria y posterior recuperación del paciente.

Palabras clave:

Periodo postoperatorio
Analgesia cirugía torácica

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Complicaciones postoperatorias
Anestesia de conducción
Bloqueo paravertebral
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Paciente y método: El propósito del estudio es evaluar el bloqueo paravertebral continuo torácico como técnica analgésica en la toracotomía. Ciento treinta y nueve pacientes sometidos a cirugía de resección pulmonar mediante toracotomía posterolateral recibieron analgesia postoperatoria mediante infusión de lidocaína al 1,5% (7-10 ml/h) a través de un catéter paravertebral torácico y durante un mínimo de 48 h. La intensidad del dolor mediante la escala analógica visual (EVA) tanto en reposo (EVA pasivo) como durante la tos incentivada (EVA activo) fue registrada al alta de la unidad de reanimación, al segundo, tercer y cuarto día postoperatorio. Se estudiaron las complicaciones postoperatorias y la necesidad de analgesia de rescate.

Resultados: Al alta de reanimación un 98,6% de los pacientes presentaron un dolor leve (EVA pasivo < 3), un 1,4% dolor moderado (EVA pasivo 4-6) y 0% un dolor severo (EVA > 6); en el 2.º día postoperatorio un 97,9% tuvieron un dolor leve, y un 1,2%, dolor moderado; en el 3.º día un 98,6%, un dolor leve, y un 0,7%, dolor moderado; y al 4.º día un 100% presentaron dolor leve. No se encontraron complicaciones derivadas de la técnica analgésica.

Conclusiones: La analgesia paravertebral torácica continua es efectiva y segura en el control del dolor postoracotomía.

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Introduction

Postoperative pain associated with thoracic surgery is generally severe in intensity and duration. Suboptimal management of this pain can reduce respiratory reserves and pulmonary volume, hinders an adequate completion of respiratory physical therapy, favours the development of atelectasis and pulmonary overinfection, and can trigger subsequent respiratory failure. Acute postoperative pain also favours the development of chronic post-thoracotomy pain syndrome.¹

Several methods for the treatment of post-thoracotomy pain have been proposed with varying success: intercostal block,² interpleural analgesia,^{2,3} cryoanalgesia,^{4,5} lumbar epidural,^{6,7} thoracic epidural,^{7,8} paravertebral block,^{9,10} i.v. opiates,^{11,12} NSAIDs,^{13,14} and transcutaneous nerve stimulation.^{15,16} Epidural analgesia has been considered for quite some time to be the gold standard for acute post-thoracotomy pain treatment.

The aim of this study is to evaluate the efficacy of continuous paravertebral blocks as a postoperative analgesic treatment for posterolateral thoracotomies.

Material and methods

We performed a prospective study with data compiled by the acute pain unit in our department corresponding to the thoracotomies performed during a 13-month period. The variables studied were: age, sex, type of surgery (lobectomy or pneumonectomy), medical background, need for postoperative mechanical ventilation, postoperative complications, point score on the visual analogue pain scale from 0-10 (VAS) (0 being the absence of pain and 10 the maximum level of pain). The VAS data were collected upon discharge (between 12 and 24 hours post-operation) from the post anaesthesia recovery unit (PARU), and the 2nd, 3rd, and

4th days following the procedure. VAS scoring was registered in resting respiratory (passive VAS) and active respiratory (active VAS) (stimulated cough, respiratory physical therapy, etc.) conditions. Pain intensity was rated as mild (VAS between 0-3), moderate (VAS between 4-6), and severe (VAS between 7-10). We also registered early postoperative complications and postoperative mortality.

All patients received the same anaesthetic protocol: balanced anaesthesia with halogenated inhalation agents (sevoflurane or desflurane), muscular relaxation with cisatracurium, and analgesia with continuous remifentanyl perfusion. After the surgery was over, the patients received intravenous doses of morphine hydrochloride at 0.15 mg/kg, 1 g of paracetamol, and 50 mg of dexametoprolfen. Whether at the start or finish of the surgery, a thoracic paravertebral catheter was placed for the administration of a 1.5% lidocaine bolus at 1 ml for every 10 cm of height, followed by a continuous infusion of 7-10 ml/h. Regardless of the timing of the catheter placement, this administration started upon surgery finalization (closing). All patients received 50 mg of dexametoprolfen every 8 hrs for 2 days and 1 g of paracetamol every 8 hrs for the entire study period. We used 50 mg of i.v. meperidine as a salvage therapy in case the VAS score surpassed 6 points at any moment during the study. All patients were evaluated 6 hrs after catheter insertion in order to ensure correct placement. If at this point the patient had presented a VAS>6 or had required more than 0.25 mg/kg of morphine, the catheter was replaced or a different analgesic regimen was established. At 4 hrs after the surgery, the patients were instructed to start respiratory physical therapy by incentive spirometry.

We used the classically described placement technique, with the patient in lateral supine or seated position. We located the T4-T6 spinous process, and made a mark 2-3 cm laterally to the side of the process corresponding to the surgery. After infiltrating with local anaesthetic, we made a puncture at this spot with a Tuohy needle at an 80° angle

until contacting the transverse process of the subjacent vertebra. If this contact was not made within 3.5 cm of the skin, the needle was retracted and reapplied at a more horizontal angle. Once the transverse process was contacted, the needle was connected to a syringe with 10 ml of saline solution, and the needle was advanced over the process until noting a loss in resistance to the saline flow (costotransverse ligament steps), or until reaching a depth of 2 cm. Once the paravertebral space was reached, 5 ml of saline solution was injected and the catheter was introduced about 3 cm into the interior of the space.

The statistical analysis was performed using SPSS 13.0 software, assessing quantitative variables using the mean (X) and standard deviation (SD), and using the Chi-squared and Student-Fisher T-tests in the comparison between groups for qualitative and quantitative variables, respectively. We established $P < .05$ as the statistical significance level.

Table 1 – Medical backgrounds of the patients

Antecedent	No. of patients
AHT	40
Ischemic heart disease	10
DM	14
Atrial fibrillation	2
Aorto-coronary bypass	1
Chronic liver disease	3
Intermittent claudication	1
Morbid obesity	3
Gastric ulcer	7
Light COPD	89
Moderate COPD	13
COPD (light FEV<80%) (moderate FEV<60%).	

Results

During the study period, we performed posterolateral thoracotomies on 143 patients, 139 of which were valid for the study, since 4 patients received other analgesic regimens (thoracic epidural catheter in 2 cases, patient-controlled analgesia with opiates in 1 case, and continuous perfusion with NSAIDs and opiates in 1 case). All patients were extubated in the operating room, but 2 patients required subsequent re-intubation and mechanical ventilation for a short period (2 hrs) due to respiratory depression.

The surgery consisted of pneumonectomies in 14 cases (10.2%), lobectomies in 114 (82.1%), extended lobectomies in 8 cases (5.6%), and a bilobectomy, a rib resection, and a mediastinal mass in 1 case each (0.7%). 115 (82.7%) of the patients were male and 24 (17.3%) were female. The mean age was 64.14 ± 21.24 years for men and 62.23 ± 12.9 years for women. No patients died following the operation (0% mortality), and all patients were discharged from the hospital.

One hundred and fifteen were males (82.7%) and 24 were females (17.3%). Medical backgrounds for the patients are summarized in Table 1. Two patients had an accidental removal of the catheter, one on the third day and one on the fourth day following the operation. Mean active VAS values were significantly higher than passive VAS values (Table 2). Intensity of the pain as categorized into light, moderate, and severe levels are summarized in Table 3 (passive values) and Table 4 (active values). Table 5 shows the number of patients who required salvage meperidine treatment. Table 6 displays the main postoperative complications.

Table 2 – Mean, minimum, and maximum values for active and passive VAS during the study

	Upon PARU discharge	2nd day post-op	3rd day post-op	4th day post-op
Passive VAS (X \pm SD)	0.65 (± 0.82)	0.92 (± 1.08)	0.75 (± 0.96)	0.64 (± 0.85)
Active VAS (X \pm SD)	2.38 (± 1.29)*	2.95 (± 1.6)*	2.7 (± 1.6)*	2.47 (± 1.5)*
DE indicates standard deviation; PARU, post anaesthesia recovery unit; VAS, value on the visual analogue scale; X: Mean.				
* $P < .05$ with respect to passive VAS.				

Table 3 – Percentage of patients with light (VAS 0-3), moderate (VAS 4-6), and severe (7-10) pain in respiratory rest (passive) during the study

Passive VAS	0-3 (light pain) n (%)	4-6 (moderate pain) n (%)	7-10 (severe pain) n (%)
Upon PARU discharge	137 (98.6)	2 (1.4)	0 (0)
2nd day post-op	136 (97.9)	3 (2.1)	0 (0)
3rd day post-op	137 (98.6)	1 (0.7)	0 (0)
4th day post-op	137 (100)	0 (0)	0 (0)
PARU indicates post anaesthesia recovery unit; VAS, visual analogue scale.			

Table 4 – Percentage of patients with light (VAS 0-3), moderate (VAS 4-6), and severe (7-10) pain in respiratory activity (active) during the study

Active VAS	0-3 (light pain) n (%)	4-6 (moderate pain) n (%)	7-10 (severe pain) n (%)
Upon PARU discharge	113 (81)	25 (17.9)	1 (0.7)
2nd day post-op	104 (74.8)	33 (23.7)	2 (1.4)
3rd day post-op	103 (74.1)	35 (25.1)	0 (0)
4th day post-op	115 (83.4)	22 (15.8)	0 (0)

PARU indicates post anaesthesia recovery unit; VAS, visual analogue scale.

Table 5 – Number of patients that required a meperidine dose during the postoperative period

	n (%)
Upon PARU discharge	0 (0%)
2nd day post-op	5 (3.5%)
3rd day post-op	1 (0.7%)
4th day post-op	0 (0%)

PARU indicates post anaesthesia recovery unit.

Table 6 – Postoperative complications (n)

	n (%)
Respiratory depression	2
Atelectasis	2
Sd. Claude-Bernard-Horner	1
Atrial fibrillation	3
Agitation/disorientation	1

Discussion

The prevalence of acute postoperative pain following a thoracotomy is very high, this being classically considered as one of the surgical procedures associated with the highest levels of pain. Controlling this postoperative pain is essential for obtaining positive results when assessing analgesic treatment efficiency. The nociceptive pathways responsible for post-thoracotomy pain are not completely understood, but the intercostal nerves, the phrenic nerve, and the vagus nerve have all been implicated. The inputs from the thoracic pleura via the intercostal nerves, from the diaphragmatic pleura via the phrenic nerve, and the lung and mediastinum via the vagus nerve are all determinants in the pain stimulus.^{17,18} The placement and presence of thoracic tubes, rib retraction with or without damage or trapping of the intercostal nerves, and surgical incisions are all causal elements for these inputs. The presence of pain in the homolateral shoulder with respect to the thoracotomy is very frequent, with an incidence that often surpasses 80%. This is due to the stimulation of the phrenic nerve during surgery.¹⁹

Infiltration with local anaesthetic of the periphrenic fatty tissue significantly reduces this pain, as does interscalene blocking of the brachial plexus.²⁰

Paravertebral blocking was first described in 1905 as an analgesic technique in abdominal surgeries. The technique is simple, and is based on the localization of the paravertebral space by testing the loss of resistance to the passage of air or saline solution, or by testing the passage of the needle through the costotransversal ligament. The administration of a local anaesthetic in this space achieves a block of the intercostal nerves, their communicating branches, and the corresponding sympathetic chain, which implies a significant sensory and sympathetic block. The extent of the sympathetic block will depend on the volume of anaesthetic solution administered. We administered a bolus of 15-20 ml, and later a continuous perfusion of 0.1ml/kg/h, which achieved a block between 4-7 metamers.

Although the efficacy of paravertebral blocks, whether for anaesthesia or analgesia, for surgery in the thoracic area has been well known for years,²¹⁻²³ only in the last five years has its use in thoracic surgery risen in incidence.^{24,25}

Hill SE et al expounded upon the high quality of the analgesic used in paravertebral blocks following thoracoscopic surgery.²⁶ Maret E et al compared patient-controlled analgesia (PCA) with morphine and continuous thoracic paravertebral blocks for post-thoracotomy analgesia, and found that paravertebral blocks achieved a significantly superior analgesia with lower incidence of secondary effects in the form of nausea, vomiting, urine retention and postoperative ileus.²⁷ Richardson J et al compared thoracic epidural analgesia and thoracic paravertebral blocks following thoracotomies, and found that the efficacy of the two methods was similar. However, the incidence of secondary effects in the form of nausea, vomiting, hypotension, and urine retention was higher in the epidural group, and respiratory mechanics and arterial oxygen saturations were higher in the paravertebral group, this patient group also yielding a lower postoperative morbidity.²⁸ In our country, Spain, several authors have found similar results.^{29,30}

A systematic review and meta-analysis of randomized studies was recently published comparing the analgesic efficacy of paravertebral blocks and thoracic epidurals for thoracotomies.³¹ Ten studies were published between 1989 and 2005, including 520 patients who received thoracotomies. The variables under study were the intensity of pain based on VAS between 4-8 hrs, and at 24 and 48 hrs, mean dosage

of opiate consumption at 24 and 48 hrs, and the number of patients who required supplementary analgesics. The results showed an absence of significant differences with respect to the quality of the analgesic used at all time periods of observation. Nor were there any differences observed in morphine consumption at 24 hrs and between 24 and 48 hrs. However, they did observe a significant reduction in the incidence of pulmonary complications, defined as the presence of pneumonia or atelectasis, in the group that received thoracic paravertebral blocks (OR, 0.36; 95% CI, 0.14-0.92). Respiratory function, which was evaluated as the percent change in peak flow, or FEV₁, also improved significantly in the paravertebral group with respect to the epidural group at 24 hrs post-operation. The improvement was attributed to the unilateral nature of the block in the case of paravertebral blocks, as opposed to the bilateral nature of the epidural, given that respiratory mechanics are better preserved in the first case. This evidence indicates that paravertebral blocks and epidurals are comparable in terms of analgesic quality, although the paravertebral block is associated with a lower incidence of pulmonary complications. Similar results were found in a recent systematic review.²⁵

Our study with over 100 consecutive patients receiving posterolateral thoracotomies attests to the high-quality control of postoperative pain achieved by using continuous paravertebral blocks, which allowed the extubation of all patients in the surgical operating room and an early commencement of respiratory physical therapy. Few complications were presented in this study, represented by 2 cases of atelectasis (one was resolved using physical therapy and the other required bronchoscopy), 2 cases of early respiratory depression, requiring re-intubation and short-term mechanical ventilation, and one case of acute postoperative confusional syndrome that lasted 2 days, in which lidocaine could have played a role as a potential neurotoxic agent.

The complications in paravertebral blocks are scarce in comparison to classic thoracic epidural analgesia, and can be summarized as: 1) unilateral sympathetic block, whereas the thoracic epidural creates a bilateral block and increases the risk of hypotension and bradycardia. Treatment includes fluid therapy, which can have repercussions in the form of increased pulmonary fluid and elevated incidence of post-pneumectomy oedema³²; 2) minimal risk of neurological damage, which is always present in epidural techniques. The incidence of epidural haematomas following the catheterization of the paravertebral space has been established at 0.0007%, and paraplegia at 0.0009%; while these incidences are low, the consequences of such an occurrence are catastrophic^{33,34}; 3) urine retention is a well-known complication in epidural analgesia, which is maximized when combined with opiate administration, a complication that is not associated with paravertebral blocks; 4) dural punctures are another complication associated with epidurals (an incidence of 1%-5%), the most common manifestation is headache that worsens with cough, which, although it is a minor complication, it can interfere markedly in respiratory physical therapy in the case of thoracic surgery³⁵; 5) absence of risk for epidural haematoma, and the lack of a need for

precautions against the placement or removal of catheters and the presence of coagulopathy, which is necessary in the case of epidural techniques³⁶; 6) paravertebral blocks are generally not associated with opioid use, whereas thoracic epidural analgesia frequently requires its use, with the most serious side effect being respiratory depression, which can be early (<2 hrs) when using fentanyl, or late (>2 hrs) when using morphine.^{37,38} The use of opiates is also associated with pruritus.

In connection with the aforementioned differences, some situations do exist that present relative or absolute contraindications for the use of epidural analgesia (increase in intracranial pressure, coagulopathy, severe spondylopathy, etc.), which do not contraindicate the use of paravertebral blocks.³⁹

In summary, thoracic paravertebral block continues to be a good alternative to classic thoracic epidural analgesia as an analgesia technique following a thoracotomy. The technical simplicity, efficacy, few side effects, high tolerance level, and few contraindications of this technique could situate it as the method of choice for this type of surgery.

Conflict of interest

The authors affirm that they have no conflicts of interest.

REFERENCES

1. Gerner P. Postthoracotomy pain management. *Anesthesiology Clin.* 2008;26:355-67.
2. Dauphin A, Lubanska-Hubert E, Young JE, Miller JD, Bennett WF, Fuller HD. Comparative study of continuous extrapleural intercostals nerve block and lumbar epidural morphine in post-thoracotomy pain. *Can J Surg.* 1997;40:431-6.
3. Broome IJ, Sherry KM, Reilly CS. A combined chest drain and intrapleural catheter for postthoracotomy pain relief. *Anesthesia.* 1993;48:724-6.
4. Gough JD, Williams AB, Vaughan RS, Khalil JF, Butchart EG. The control of post-thoracotomy pain. A comparative evaluation of thoracic epidural fentanyl infusions and cryo-analgesia. *Anesthesia.* 1988;43:780-3.
5. Joucken K, Michel L, Schoevaerdts JC, Mayné A, Randour P. Cryoanalgesia for post-thoracotomy pain relief. *Acta Anesthesiol Belg.* 1987;38:179-83.
6. Baxter AD, Laganière S, Samson B, Stewart J, Hull K, Goernert L. A comparison of lumbar epidural and intravenous fentanyl for post-thoracotomy analgesia. *Can J Anaesth.* 1994;41:184-91.
7. Hurford WE, Dutton RP, Alfille PH, Clement D, Wilson RS. Comparison of thoracic and lumbar epidural infusions of bupivacaine and fentanyl for post-thoracotomy analgesia. *J Cardiothoracic Vasc Anesth.* 1993;7:521-55.
8. Burgess FW, Anderson DM, Colonna D, Cavanaugh DG. Thoracic epidural analgesia with bupivacaine and fentanyl for postoperative thoracotomy pain. *J Cardiothoracic Vasc Anesth.* 1994;8:420-4.
9. Bimston DN, McGee JP, Liptay MJ, Fry WA. Continuous paravertebral extrapleural infusion for post-thoracotomy pain management. *Surgery.* 1999;126:650-6.
10. Vogt A, Singer DS, Theurillat C, Curatolo M. Single-injection thoracic paravertebral block for postoperative pain treatment after thoracoscopic surgery. *Br J Anaesth.* 2005;95:816-21.

11. Della Rocca G, Coccia C, Pompei L, Costa MG, Pierconti F, Di Marco P, et al. Post-thoracotomy analgesia: epidural vs intravenous morphine continuous infusion. *Minerva Anesthesiol.* 2002;68:681-93.
12. Grant RP, Dolman JF, Harper JA, White SA, Parsons DG, Evans KG, et al. Patient-controlled lumbar epidural fentanyl compared with patient-controlled intravenous fentanyl for post-thoracotomy pain. *Can J Anaesth.* 1992;39:214-9.
13. McCroy C, Diviney D, Moriaty J, Luke D, Fitzgerald D. Comparison between repeat bolus intrathecal morphine and an epidurally delivered bupivacaine and fentanyl combination in the management of post-thoracotomy pain with or without cyclooxygenase inhibition. *J Cardiothorac Vasc Anaesth.* 2002;16:607-11.
14. Perttunen K, Kalso E, Heinonen J, Salo J. IV diclofenac in post-thoracotomy pain. *Br J Anaesth.* 1992;68:474-80.
15. Solak O, Turna A, Pekcolaklar A, Metin M, Sayar A, Solak O, et al. Transcutaneous electric nerve stimulation in post-thoracotomy pain: a randomized prospective study. *Thorac Cardiovasc Surg.* 2007;55:182-5.
16. Miller-Jones CM, Phillips D, Pitchford EA, Smallpeice CJ. Transcutaneous electric nerve stimulation in post-thoracotomy pain relief. *Anesthesia.* 1980;35:1018.
17. Conacher ID. Pain relief after thoracotomy. *Br J Anaesth.* 1990;65:806-12.
18. Benedetti F, Vighetti S, Ricco C, Amanzio M, Bergamasco L, Casadio C, et al. Neurophysiologic assessment of nerve impairment in posterolateral and muscle-sparing thoracotomy. *J Thorac Cardiovasc Surg.* 1998;115:841-7.
19. Pennefather SH, Akrofi ME, Kendall JB, Russell GH, Scawn ND. Ipsilateral shoulder pain after thoracotomy with epidural analgesia: the influence of phrenic infiltration with lidocaine. *Anesth Analg.* 2001;93:260-4.
20. Barak M, Iaroshevski D, Poppa E, Ben-Nun A, Katz Y. Low volume interscalene brachial plexus block for post-thoracotomy shoulder pain. *J Cardiothorac Vasc Anaesth.* 2007;21:554-7.
21. Klein SM, Bergh A, Steele SM. Thoracic paravertebral block for breast surgery. *Anesth Analg.* 2000;90:1402-5.
22. Conacher ID, Kokri M. Postoperative paravertebral blocks for thoracic surgery. A radiological appraisal. *Br J Anaesth.* 1987;59:155-61.
23. Purcell-Jones G, Justins DM. Postoperative paravertebral blocks for thoracic surgery. *Br J Anaesth.* 1988;61:369-70.
24. Myles PS, Bain C. Underutilization of paravertebral block in thoracic surgery. *J Cardiothorac Vasc Anaesth.* 2006;20:635-8.
25. Joshi GP, Bonnet F, Shah R, Wilkinson RC, Camu F, Fischer B, et al. A systematic review of randomized trials evaluating regional techniques for postthoracotomy analgesia. *Anesth Analg.* 2008;107:1026-240.
26. Hill SE, Keller RA, Stafford-Smith M, Grichnik K, White WD, D'Amico TA, et al. Efficacy of single-dose, multilevel paravertebral nerve blockade for analgesia after thoracoscopic procedures. *Anesthesiology.* 2006;104:1047-53.
27. Marret E, Bazelly B, Taylor G, Lember N, Deleuze A, Mazoit JX, et al. Paravertebral block with ropivacaine 0.5% versus systemic analgesia for pain relief after thoracotomy. *Ann Thorac Surg.* 2005;79:2109-13.
28. Richardson J, Sabanathan S, Jones J, Shah RD, Cheema S, Mearns AJ. A prospective, randomized comparison of preoperative and continuous balanced epidural or paravertebral bupivacaine on post-thoracotomy pain, pulmonary function and stress responses. *Br J Anaesth.* 1999;83:387-92.
29. Navlet MG, Garutti I, Olmedilla L, Pérez-Peña JM, San Joaquin MT, Martinez-Ragues G, et al. Paravertebral ropivacaine, 0.3%, and bupivacaine, 0.25%, provide similar pain relief after thoracotomy. *J Cardiothorac Vasc Anaesth.* 2006;20:644-7.
30. Cantó M, Sanchez MJ, Casas MA, Bataller ML. Bilateral paravertebral blockade for conventional cardiac surgery. *Anaesthesia.* 2003;58:367-70.
31. Davies RG, Myles PS, Graham JM. A comparison of analgesic efficacy and side effects of paravertebral vs epidural blockade for thoracotomy-asystematic review and meta-analysis of randomized trials. *Br J Anaesth.* 2006;96:418-26.
32. Slinger PD. Perioperative fluid management for thoracic surgery: the puzzle of postpneumonectomy pulmonary edema. *J Cardiothorac Vasc Surg.* 1995;9:442-5.
33. Renck R, McCartney CJ, Chan VW. Neurological complications after regional anesthesia: contemporary estimates of risk. *Anesth Analg.* 2007;104:965-74.
34. Tanaka K, Watanabe R, Harada T. Extensive application of epidural anesthesia and analgesia in university hospital: incidence of complications related to technique. *Reg Anesth.* 1993;18:34-8.
35. Giebler RM, Scherer RU, Peters J. Incidence of neurologic complications related to thoracic epidural catheterisation. *Anesthesiology.* 1995;86:55-63.
36. Dockman KC, Shedd SA, Spetzler RF. Spinal epidural hematoma associated with epidural anesthesia: complications of systemic heparinization in patients receiving peripheral vascular thrombolytic therapy. *Anesthesiology.* 1997;86:55-63.
37. Chaney MA. Side effects of intrathecal and epidural opioids. *Can J Anaesth.* 1995;83:387-92.
38. Vilà E, García-Guasch R, Sabaté S, Lucas M, Canet J, Grupo ANESCAT. Anesthesia in thoracic surgery in Catalonia: results of a survey carried out in 2003. *Arch Bronconeumol.* 2008;444:586-90.
39. Karkamar MK, Chui PT, Joynt GM. Thoracic paravertebral block for management of pain associated with multiple fractured ribs in patients with concomitant lumbar spinal trauma. *Reg Anesth Surg.* 1990;49:854.