Role of Epidural and Patient-Controlled Analgesia in Site-Specific Laparoscopic Colorectal Surgery

Jan P. Kamiński, MD, MBA, Ajit Pai, MCh, Luay Ailabouni, MD, John J. Park, MD, Slawomir J. Marecik, MD, Leela M. Prasad, MD, Herand Abcarian, MD

ABSTRACT

Background and Objectives: Limited data are available comparing epidural and patient-controlled analgesia in site-specific colorectal surgery. The aim of this study was to evaluate 2 modes of analgesia in patients undergoing laparoscopic right colectomy (RC) and low anterior resection (LAR).

Methods: Prospectively collected data on 433 patients undergoing laparoscopic or laparoscopic-assisted colon surgery at a single institution were retrospectively reviewed from March 2004 to February 2009. Patients were divided into groups undergoing RC (n = 175) and LAR (n = 258). These groups were evaluated by use of analgesia: epidural analgesia, "patient-controlled analgesia" alone, and a combination of both. Demographic and perioperative outcomes were compared.

Results: Epidural analgesia was associated with a faster return of bowel function, by 1 day ($P < .001$), in patients who underwent LAR but not in the RC group. Delayed return of bowel function was associated with increased operative time in the LAR group ($P = .05$), patients with diabetes who underwent RC ($P = .037$), and patients after RC with combined analgesia ($P = .011$). Mean visual analogue scale pain scores were significantly lower with epidural analgesia compared with patient-controlled analgesia in both LAR and RC groups ($P < .001$).

Conclusion: Epidural analgesia was associated with a faster return of bowel function in the laparoscopic LAR group but not the RC group. Epidural analgesia was superior to patient-controlled analgesia in controlling postoperative pain but was inadequate in 28% of patients and needed the addition of patient-controlled analgesia.

Department of Surgery, University of Illinois Metropolitan Group Hospitals, Chicago, Illinois (Dr Kamiński); Division of Colon and Rectal Surgery, Advocate Lutheran General Hospital, Park Ridge, Illinois (Drs Pai, Ailabouni, Park, Marecik, and Prasad); Division of Colon and Rectal Surgery, John H. Stroger Hospital of Cook County, Chicago, Illinois (Dr Abcarian).

Address correspondence to: John J. Park, MD, Advocate Lutheran General Hospital, Division of Colon and Rectal Surgery, 1550 N Northwest Highway, Suite 107, Park Ridge, IL 60068. Telephone: 847-759-1110; E-mail: jpark18@aol.com

INTRODUCTION

Optimal pain control is of vital importance in the postoperative period for both patient comfort and rapid recovery. Although opioids have been a mainstay in the management of postoperative pain, systemic opioids can prolong postoperative ileus and delay the recovery of colonic motility.[1] Following a colorectal resection, return of bowel function (ROBF) governs the tolerance of oral feeding and indirectly influences the duration of postoperative hospital stay. Epidural analgesia has been shown in numerous studies to decrease the duration of ileus[2] and provide superior pain control compared with intravenous (IV) patient-controlled opioid analgesia.[3]

A number of publications have shown that thoracic epidural anesthesia (TEA) has a beneficial effect on the resolution of ileus compared with conventional use of IV narcotics in the postoperative period following open or laparoscopic colorectal surgery.[4,5] A few studies showed no difference or worse outcomes in the resolution of ileus.[6,7] Although the vast majority of studies confirm the superiority of epidural catheter-based delivery in pain control compared with other methods,[8,9] there is a paucity of literature on the effect of TEA or IV narcotics administered through patient-controlled analgesia (PCA) on site-specific colectomies.

The aim of this study was to compare TEA with PCA in patients undergoing laparoscopic colorectal surgery. Efficacy, adequacy, ROBF, and length of hospital stay associated with each mode of analgesia on patients undergoing right colectomy (RC) and those undergoing low anterior resection (LAR) were evaluated.

METHODS

We retrospectively reviewed a prospectively collected database at a tertiary care center over a 5-year period between March 2004 and February 2009. All patients under-

went either elective laparoscopic or laparoscopic-assisted colorectal resection by 1 of 3 colorectal surgeons. Hand-assisted procedures most commonly involved a Pfannenstiel incision of approximately 6 cm in length. Procedures converted to open and those not involving bowel resection were excluded. From the 560 patients identified, in-hospital deaths (n = 3), patients undergoing additional procedures under the same anesthesia (n = 6), patients receiving neither an epidural nor PCA (n = 10), patients undergoing procedures other than RC or LAR (n = 103), and patients whose hospital charts could not be adequately evaluated (n = 5) were also excluded. The remaining 433 patients were categorized into 2 groups, the RC group (n = 175) and the LAR group (n = 258).

All patients received standard preoperative bowel preparation on the day before surgery and prophylactic antibiotics prior to induction of anesthesia. Each patient was offered TEA. Risks and benefits were discussed with all patients by the anesthetist. Patient's preference was final. The epidural catheter was inserted before induction of general anesthesia and its position confirmed with a single bolus injection of 1% lidocaine. Intraoperative epidural use with local anesthetic and/or opioid varied between anesthesiologists, so only postoperative opioid use was considered in this study. Postoperative epidural analgesia was begun in the recovery room and was administered by continuous infusion with an additional patient-controlled bolus capability. A combination of local anesthetic (0.1% bupivacaine) and opioid (fentanyl [2–5 μg/mL] or hydromorphone [10 μg/mL]) was used in most patients. The anesthesiology pain service monitored epidural dosage, efficacy, and adverse effects. PCA was also begun in the immediate postoperative period with either morphine or hydromorphone in standard dosage and lockout regimens. IV bolus morphine, hydromorphone, and ketorolac were available for breakthrough pain and were used on an as-needed basis. For patients who did not achieve adequate pain control with TEA, PCA was added to the TEA (ensuring that only a local anesthetic was used for the epidural component to avoid overdosing on narcotics).

Prophylaxis for venous thrombosis was provided with unfractionated heparin in the epidural group and with low–molecular weight heparin in those receiving PCA.

The nursing protocol at the study institution included mandatory documentation of pain scores on a visual analogue scale for every nursing shift. Accurate data on pain scores were therefore available for all patients in both groups. The highest recorded pain score was noted on each of the first 3 postoperative days, beginning the day after surgery.

Daily progress notes provided data on the postoperative course, including time to first flatus, which was accurately entered for all patients by the resident physician on the case. For patients with stomas, the appearance of gas in the stoma appliance was considered as passage of flatus.

On the first postoperative day, patients were encouraged to ambulate and were offered tea or coffee. Subsequently, diet was advanced to full liquids upon passage of flatus and then to solids as tolerated. An orogastric tube was inserted intraoperatively and removed at the end of the procedure. Nasogastric tubes were reinserted only in patients with postoperative ileus and significant abdominal distension and vomiting. Patients were discharged once they tolerated a soft diet, and pain was controlled with oral medication.

The effect of age, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, diabetes mellitus, operative time, mode of analgesia on pain score and ROBF, and length of stay were evaluated. ROBF was defined by day of first flatus.

The data were statistically evaluated with SPSS for Windows version 17.0 (SPSS, Inc, Chicago, Illinois) using the Pearson χ^2 test, the Student t test, and the Mann-Whitney test as appropriate, with P values < .05 regarded as significant. The study was approved by the hospital's institutional review board.

RESULTS

Table 1 demonstrates the demographics between the RC and LAR groups. No major differences were seen between the 2 groups with regard to age, sex, BMI, ASA class, diabetes, and pathology (malignant vs benign). The only major difference was seen in the procedure performed. All procedures in the RC group were performed via the laparoscopic method. However, 21.8% of LARs were performed laparoscopically, while 78.2% were performed via the hand-assisted laparoscopic surgical method.

In the RC group, 75 patients received TEA and 70 received PCA, while 30 patients needed the addition of PCA to TEA for adequate pain control. When the LAR group was studied, 133 and 73 patients received TEA and PCA, respectively, while 52 patients needed combinations of TEA and PCA for adequate pain control. Of the 290 patients receiving TEA, pain control was inadequate in 82 patients

Table 1.
Demographics of Right Hemicolectomy Versus LAR

Variable	Right Hemicolectomy	LAR
Age, mean ± SD, y	63.3 ± 20.3	63.1 ± 14.2
Men	45%	51.1%
BMI, mean ± SD, kg/m^2	26.2 ± 5.8	27.8 ± 5.9
ASA Class		
I	10.6%	7.9%
II	57.1%	57.9%
III	32.3%	33.9%
DM	15.3%	16.5%
Cancer	43.4%	46.6%
Procedure		
Laparoscopic	100%	21.8%
HALS	0%	78.2%

ASA, American Society of Anesthesiologists; BMI, body mass index; DM, diabetes mellitus; HALS, hand-assisted laparoscopic surgery; LAR, low anterior resection.

Table 2.
Return of Bowel Function in Patients Undergoing Laparoscopic RC Versus Laparoscopic LAR

Mode of Analgesia	n	Days to First Flatus,* Mean ± SD	P
RC (n = 175)			
TEA	75	3.5 ± 1.3	
PCA	70	3.9 ± 1.3	
TEA + PCA	30	4.2 ± 1.4	.011
LAR (n = 258)			
TEA	133	3.0 ± 1.5	<.001
PCA	73	3.9 ± 1.1	
TEA + PCA	52	3.9 ± 1.7	

LAR, low anterior resection; PCA, patient-controlled analgesia; RC, right colectomy; TEA, thoracic epidural anesthesia.
*Return of bowel function.

(28%), requiring the addition of PCA for better pain control **(Figure 1)**.

Epidural catheter insertion attempts failed in only 6 patients (1.48%), who then received PCA. Epidural-related adverse effects were seen in 22 of successfully inserted epidurals (7.8%) and presented largely as self-limiting sensorimotor neuropathy. In addition, 1 patient had pain at the site of the epidural, necessitating its removal, and 3 patients had epidural-related hypotension. There were no cases of epidural abscess. One patient had erythema and pain at the epidural site, but cultures and imaging were negative for infection and abscess. Apart from 1 patient with an allergic reaction to hydromorphone, there was no morbidity associated with PCA use.

There was no statistically significant difference between the use of TEA or PCA on ROBF in the RC group. When PCA was added to TEA, ROBF was delayed by 0.7 days, which was statistically significant (P = .011) **(Table 2)**.

Resolution of ileus was also delayed in patients with diabetes who underwent RC (P = .037). Age, BMI, ASA score, and operative time did not have a statistically significant effect on ROBF in this group.

In the LAR group, patients receiving TEA showed faster ROBF, by 1 day, compared with the other 2 modalities (P < .001) **(Table 2)**. Prolonged operative time was associated with delayed resolution of ileus in this group (P = .05). Age, BMI, ASA score, and diabetes mellitus did not have statistically significant effects on ROBF in this group. The mean visual analogue scale pain scores were significantly lower for the epidural group on each of the first 3 postoperative days (P < .001) **(Table 3)**.

DISCUSSION

Postoperative pain is inevitable after major surgery. Thus, surgeons should be aware of pain control options and their risks and benefits. It has been shown that most patients after colorectal surgery who received epidural analgesia alone reported significantly better postoperative

	RC (n=175)	LAR (n=258)	Total (n=433)
TEA	75	133	208
PCA	70	73	143
TEA + PCA	30	52	82 (28%)

Figure 1. Epidural versus Patient-Controlled Analgesia in Patients undergoing Laparoscopic RC and Laparoscopic LAR. LAR, low anterior resection; RC, right colectomy; PCA, patient-controlled analgesia; TEA, thoracic epidural anesthesia.

Table 3.
Mean Visual Analogue Scale Pain Scores in Epidural versus Patient-Controlled Analgesia

Postoperative Day	Pain Score, Mean ± SD		
	Epidural (n = 252)	PCA (n = 173)	*P*
1	3.8 ± 1.7	4.6 ± 2.0	<.001
2	3.1 ± 1.6	3.8 ± 1.5	<.001
3	2.7 ± 1.5	3.3 ± 1.5	<.001

PCA, patient-controlled analgesia.

pain scores than those using IV narcotics alone.[10] Neudecker et al[11] and Turunen et al[12] demonstrated that patients after laparoscopic sigmoidectomy receiving epidural analgesia also required the addition of IV narcotics for adequate pain control. Although patients after laparoscopic sigmoidectomy with epidural analgesia required fewer IV narcotics than those who received only IV narcotics for pain, no difference was seen in ROBF between the 2 groups. Our study confirmed the superiority of TEA to PCA with regard to pain control on the basis of mean visual analogue scale scores for the first 3 postoperative days (*P* < .001). In addition, we showed that epidural analgesia shortened time to ROBF by 1 day in LAR group but not in RC patients. Twenty-eight percent of all patients with epidurals required additional PCA for breakthrough pain. By adding PCA, the ROBF in the RC patients was delayed by 0.7 days, which was statistically significant (*P* = .011).

These results imply that resolution of ileus depends on which segment of the large bowel is resected. Prolonged operative time was associated with delay in ROBF in the LAR group and not in the RC group (*P* = .05). One reason for this finding may be that LARs are technically more demanding and require additional manipulation of the bowel compared with RCs. Indeed, it has been demonstrated that gut manipulation results in postoperative ileus by eliciting an intestinal inflammatory response.[13–16] Because most RC cases are technically less challenging compared with LAR, it is likely that the extent of bowel manipulation, not necessarily the operative time, plays a significant role in prolongation of postoperative ileus in LAR group. In addition, even small amounts of narcotics can counteract the benefit of epidural analgesia in achieving faster ROBF.

Recent literature has suggested that the outcomes of using epidural analgesia compared with PCA might be no different or worse, especially in the context of an enhanced recovery pathway.[6,17–19] Furthermore, new medications and methods such as IV acetaminophen, alvimopan, and transverse abdominus plane blocks have been shown to accelerate ROBF and decrease length of stay in patients undergoing colorectal procedures.[20–22] Because our data are almost 5 years old, new medications and multimodal analgesia that improve ROBF should be taken into account. However, our study demonstrates differences between epidural analgesia and PCA in site-specific colectomies that is unique and important as this has not been presented in the literature before.

Diabetic autonomic neuropathy can cause gastrointestinal motility disorder and significantly delay colonic transit time compared with normal individuals.[23,24] Our study showed that diabetes exerted a negative impact on ROBF in the RC group and not in the LAR group, irrespective of the mode of analgesia. It is not entirely clear why one segment of colon would be more affected by diabetes than another; however, Jung et al[25] found that transit time was longer in the left colon than in the right colon in diabetic patients with constipation. It is clear that diabetes affects gut motility via many complex avenues, including enteric nerves, interstitial cells of Cajal, neurotransmitters, and gastrointestinal smooth muscle.[26] Because segmental contractions and certain interstitial cells of Cajal are present solely in the proximal part of the colon, it is evident that the colon has side-specific differences with regard to the previous parameters discussed.[27,28] We speculate that diabetes might affect one side more so than the other through molecular- and cellular-based mechanisms that are not entirely understood as of yet.

In patients undergoing colorectal surgery, epidural analgesia has also been associated with better postoperative pulmonary function,[29,30] reduction in thromboembolic events,[31] beneficial effect on postoperative nitrogen balance,[32] and better functional outcomes and quality of life.[33] However, although largely safe, epidural analgesia is not entirely free of risks and is costlier by itself.[19,34,35] A 0.16% to 1.3% rate of accidental dural puncture with a 16% to 86% incidence of postoperative headaches has been reported.[36] Nerve root irritation leading to radicular pain or transient paresthesia is probably the most common side effect (6%)[37,38] but is usually self-limiting and rarely disabling. With the use of strict aseptic techniques, infusion pumps instead of syringes and daily site checks, catheter site infection with subsequent abscess formation is fortunately rare and has been reported in only 0.12% of patients. Hematoma formation at the time of catheter insertion or removal is rare, and < 1 in 150,000 patients will

face this complication. Urinary tract infections are associated with epidural analgesia, but the incidence of respiratory failure, pneumonia, anastomotic leak, ileus, or urinary retention in patients with epidural analgesia is not increased compared with patients without epidural analgesia.[19] The incidence of sensorimotor complications in our study was 6.5%, which compares well with reported literature. Considering all complications collectively, we had a 7.8% incidence of epidural-related adverse events, which were all minor and self-limiting.

The retrospective nature of the analysis, though the data were prospectively collected, along with potential bias in the patient selection constitute the main limitations of this study. Therefore, a well-controlled, prospective randomized trial comparing these 2 methods of postoperative pain control as well as newer IV nonnarcotic analgesics is warranted.

CONCLUSIONS

Epidural anesthesia was associated with faster ROBF in the LAR group but not in the laparoscopic RC group. The addition of IV narcotics to the epidural eliminated the epidural's benefit on ROBF in the LAR group. Diabetes seemed to have a negative influence on ROBF in the laparoscopic RC group but not the LAR group, irrespective of mode of analgesia given. Epidural analgesia is superior to PCA in controlling postoperative pain but is costlier by itself and inadequate in 28% of patients needing addition of PCA in this study.

References:

1. Cali RL, Meade PG, Swanson MS, et al. Effect of morphine and incision length on bowel function after colectomy. *Dis Colon Rectum*. 2000;43(2):163–168.

2. Liu SS, Carpenter RL, Mackey DC, et al. Effects of perioperative analgesic technique on rate of recovery after colon surgery. *Anesthesiology*. 1995;83(4):757–765.

3. Wu CL, Cohen SR, Richman JM, et al. Efficacy of postoperative patient-controlled and continuous infusion epidural analgesia versus intravenous patient-controlled analgesia with opioids: a meta-analysis. *Anesthesiology*. 2005;103(5):1079–1088.

4. Carli F, Trudel JL, Belliveau P. The effect of intraoperative thoracic epidural anesthesia and postoperative analgesia on bowel function after colorectal surgery: a prospective, randomized trial. *Dis Colon Rectum*. 2001;44(8):1083–1089.

5. Khan SA, Khokhar HA, Nasr AR, et al. Effect of epidural analgesia on bowel function in laparoscopic colorectal surgery: a systematic review and meta-analysis. *Surg Endosc*. 2013;27(7): 2581–91.

6. Levy BF, Scott MJ, Fawcett W, et al. Randomized clinical trial of epidural, spinal or patient-controlled analgesia for patients undergoing laparoscopic colorectal surgery. *Br J Surg*. 2011; 98(8):1068–1078.

7. Levy BF, Tilney HS, Dowson HM, et al. A systematic review of postoperative analgesia following laparoscopic colorectal surgery. *Colorectal Dis*. 2010;12(1):5–15.

8. Senagore AJ, Delaney CP, Mekhail N, et al. Randomized clinical trial comparing epidural anaesthesia and patient-controlled analgesia after laparoscopic segmental colectomy. *Br J Surg*. 2003;90(10):1195–1199.

9. Zingg U, Miskovic D, Hamel CT, et al. Influence of thoracic epidural analgesia on postoperative pain relief and ileus after laparoscopic colorectal resection: benefit with epidural analgesia. *Surg Endosc*. 2009;23(2):276–282.

10. Fotiadis RJ, Badvie S, Weston MD, et al. Epidural analgesia in gastrointestinal surgery. *Br J Surg*. 2004;91(7):828–841.

11. Neudecker J, Schwenk W, Junghans T, et al. Randomized controlled trial to examine the influence of thoracic epidural analgesia on postoperative ileus after laparoscopic sigmoid resection. *Br J Surg*. 1999;86(10):1292–1295.

12. Turunen P, Carpelan-Holmstrom M, Kairaluoma P, et al. Epidural analgesia diminished pain but did not otherwise improve enhanced recovery after laparoscopic sigmoidectomy: a prospective randomized study. *Surg Endosc*. 2009; 23(1):31–37.

13. Kalff JC, Schraut WH, Simmons RL, et al. Surgical manipulation of the gut elicits an intestinal muscularis inflammatory response resulting in postsurgical ileus. *Ann Surg*. 1998;228(5): 652–663.

14. Miedema BW, Johnson JO. Methods for decreasing postoperative gut dysmotility. *Lancet Oncol*. 2003;4(6):365–372.

15. Schwarz NT, Beer-Stolz D, Simmons RL, et al. Pathogenesis of paralytic ileus: intestinal manipulation opens a transient pathway between the intestinal lumen and the leukocytic infiltrate of the jejunal muscularis. *Ann Surg*. 2002;235(1):31–40.

16. Kalff JC, Carlos TM, Schraut WH, et al. Surgically induced leukocytic infiltrates within the rat intestinal muscularis mediate postoperative ileus. Gastroenterology 1999;117(2):378–387.

17. Hubner M, Blanc C, Roulin D, et al. Randomized clinical trial on epidural versus patient-controlled analgesia for laparoscopic colorectal surgery within an enhanced recovery pathway. *Ann Surg*. In press.

18. Zutshi M, Delaney CP, Senagore AJ, et al. Randomized controlled trial comparing the controlled rehabilitation with early

ambulation and diet pathway versus the controlled rehabilitation with early ambulation and diet with preemptive epidural anesthesia/analgesia after laparotomy and intestinal resection. *Am J Surg*. 2005;189(3):268–272.

19. Halabi WJ, Kang CY, Nguyen VQ, et al. Epidural analgesia in laparoscopic colorectal surgery: a nationwide analysis of use and outcomes. *JAMA Surg*. 2014;149(2):130–136.

20. Keller DS, Stulberg JJ, Lawrence JK, et al. Process control to measure process improvement in colorectal surgery: modifications to an established enhanced recovery pathway. *Dis Colon Rectum*. 2014;57(2):194–200.

21. Delaney CP, Wolff BG, Viscusi ER, et al. Alvimopan, for postoperative ileus following bowel resection: a pooled analysis of phase III studies. *Ann Surg*. 2007;245(3):355–363.

22. Ventham NT, O'Neill S, Johns N, et al. Evaluation of novel local anesthetic wound infiltration techniques for postoperative pain following colorectal resection surgery: a meta-analysis. *Dis Colon Rectum*. 2014;57(2):237–250.

23. Rosztoczy A, Roka R, Varkonyi TT, et al. Regional differences in the manifestation of gastrointestinal motor disorders in type 1 diabetic patients with autonomic neuropathy. *Z Gastroenterol*. 2004;42(11):1295–1300.

24. Iida M, Ikeda M, Kishimoto M, et al. Evaluation of gut motility in type II diabetes by the radiopaque marker method. *J Gastroenterol Hepatol*. 2000;15(4):381–385.

25. Jung HK, Kim DY, Moon IH, et al. Colonic transit time in diabetic patients—comparison with healthy subjects and the effect of autonomic neuropathy. *Yonsei Med J*. 2003;44(2):265–272.

26. Yarandi SS, Srinivasan S. Diabetic gastrointestinal motility disorders and the role of enteric nervous system: current status and future directions. *Neurogastroenterol Motil*. 2014;26(5):611–624.

27. Bassotti G, Germani U, Morelli A. Human colonic motility: physiological aspects. *Int J Colorectal Dis*. 1995;10(3):173–180.

28. Camborova P, Hubka P, Sulkova I, et al. The pacemaker activity of interstitial cells of Cajal and gastric electrical activity. *Physiol Res*. 2003;52(3):275–284.

29. Bredtmann RD, Kniesel B, Herden HN, et al. [The effect of continuous thoracic peridural anesthesia on the pulmonary function of patients undergoing colon surgery. Results of a randomized study of 116 patients] [article in German]. *Reg Anaesth*. 1991;14(1):2–8.

30. Simpson T, Wahl G, DeTraglia M, et al. A pilot study of pain, analgesia use, and pulmonary function after colectomy with or without a preoperative bolus of epidural morphine. *Heart Lung*. 1993;22(4):316–327.

31. Ryan P, Schweitzer SA, Woods RJ. Effect of epidural and general anaesthesia compared with general anaesthesia alone in large bowel anastomoses. A prospective study. *Eur J Surg*. 1992; 158(1):45–49.

32. Vedrinne C, Vedrinne JM, Guiraud M, et al. Nitrogen-sparing effect of epidural administration of local anesthetics in colon surgery. *Anesth Analg*. 1989;69(3):354–359.

33. Mann C, Pouzeratte Y, Boccara G, et al. Comparison of intravenous or epidural patient-controlled analgesia in the elderly after major abdominal surgery. *Anesthesiology*. 2000;92(2): 433–441.

34. Giebler RM, Scherer RU, Peters J. Incidence of neurologic complications related to thoracic epidural catheterization. *Anesthesiology*. 1997;86(1):55–63.

35. Paulsen EK, Porter MG, Helmer SD, et al. Thoracic epidural versus patient-controlled analgesia in elective bowel resections. *Am J Surg*. 2001;182(6):570–577.

36. Tanaka K, Watanabe R, Harada T, et al. Extensive application of epidural anesthesia and analgesia in a university hospital: incidence of complications related to technique. *Reg Anesth*. 1993;18(1):34–38.

37. Horlocker TT, Wedel DJ. Neurologic complications of spinal and epidural anesthesia. *Reg Anesth Pain Med*. 2000;25(1):83–98.

38. Kane RE. Neurologic deficits following epidural or spinal anesthesia. *Anesth Analg*. 1981;60(3):150–161.