

Equipment and Monitoring

- Standard ASA monitoring
 - Fluoroscopy
 - Sterile prep, and drape
 - Skin local anesthesia prior to any needle larger than 25G (unless sedation is used)
 - Coaxial view is always used to advance needle, unless otherwise specified
 - CPR equipment and medications available
 - IV antibiotics single-dose preoperative is recommended
 - 13–15G 3.5 inch (90 mm) to 6 inch (150 mm) straight or Coude epidural needle
 - Saline 5–15 ml
 - Spinal cord stimulator lead, anchors, tunneling tools, extension cables, and IPG/receiver
 - Loss of resistance (LOR) syringe
 - 2.0 nylon/vicryl, 2.0 silk, 3.0 vicryl sutures
 - Occlusive bandage—if possible silver impregnated
 - Bacitracin in saline for wound irrigation
- Leg pain
 - Epidural entry level: L2–3, L3–4
 - Level of tip of the lead: generally, T9–10
 - Foot pain—epidural entry level: L2–3, L3–4
 - Level of tip of lead: T11-L1
 - Arm pain
 - Epidural entry level: T2–3 to T5–6
 - Level of tip of the lead: C3–4
 - Neck pain
 - Epidural entry level: T4–5, T5–6
 - Level of tip of the lead: C2–3
 - Abdominal pain
 - Epidural entry level: L2–3, L1–2
 - Level of tip of the lead: T4–5 to 5–6

The above levels reflect general concepts. The levels of epidural entry and target level for the lead may vary based on patient size, anatomy, previous spinal surgery, pain location, or other circumstances. For traditional tonic stimulation, it is important to overlap the areas of pain with a sensation of paresthesia. More recently, a number of novel waveforms and frequencies that do not require a paresthesia have become clinically available. Placement for these devices tends to have a set anatomic location. Burst and high frequency are placed between T8 and T9 for low back pain and at C2–3 for neck pain with or without radiculopathy.

Anatomy

Target is the posterior epidural space, to stimulate the dorsal columns with traditional tonic stimulation

- Back pain
 - Epidural entry level: L2–3 or L3–4
 - Level of top of the lead: T8–11

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Structures to Keep in Mind and Possible Complications

- Dura puncture → spinal headache
- Dural puncture and intrathecal medication administration → sudden onset motor block, cardiac/respiratory arrest, death
- Subdural puncture → spinal cord compression, or medication related sudden onset motor block, cardiac/respiratory arrest, death

- Epidural blood vessels → bleeding, spinal cord compression and epidural hematoma formation, possible onset even after procedure is completed. This can also occur with insertion or removal of the electrodes
- Direct spinal cord damage/injection → loss of bladder/bowel function, various paresthesias, motor loss, depending on injected amount, syrinx formation, quadriplegia, death
- Epidural infection → abscess
- Exiting nerve roots → nerve injury
- Procedure should not be performed while patient is taking certain anticoagulants
- Heavy sedation should be preferably avoided for routine procedures
- Infection
- Bleeding
- Postprocedure pain
- Vasovagal reaction
- Allergic reaction
- True anteroposterior (AP) image, spinous processes in midline (Fig. 14.1)
- Slight caudad tilt in difficult cases may facilitate visualizing the interlaminar opening (Fig. 14.2a)
- **Non-coaxial view technique:**
 - Entry 2 vertebral bodies below target interlaminar space, in order to reach epidural space utilizing a shallow angle, entering in the midline. This will facilitate driving the lead midline in the posterior epidural space
- **Coaxial view technique:**
 - 30° caudad tilt of the C-arm
 - Skin entry just paramedian of the spinous process, immediately below the target interlaminar space

Fluoroscopy Technique, Target Localization

- Patient in prone position, with pillows under abdomen to decrease lumbar lordosis



Fig. 14.1 AP image of the thoracolumbar spine, true AP, spinous processes in the midline. Complete Anatomy image

Procedure Steps

- Target the lamina caudad from the target interlaminar epidural space, in a paramedian approach (Fig. 14.2b, c)
- Walk needle off the cephalad edge of lamina to engage in ligamentum flavum
- Advance needle with LOR technique
- After LOR, check lateral view to see the depth of the needle tip (Fig. 14.3)
- Thread lead to confirm epidural position (Fig. 14.4a, b)
- Advance electrode cephalad in the posterior epidural space (Fig. 14.5)
- Use a forefinger/thumb “pill rolling” technique as the lead is advanced to maintain lead position as close as possible to the anatomical midline
- After lead placement, for tonic stimulation test, stimulation is performed with the patient awake. For paresthesia stimulation, the leads are left in an anatomic location
- Analgesia/paresthesia is reported by the patient and should cover the painful area for tonic stimulation
- Secure leads to fascia or skin once best pain area coverage is obtained
- When leads are in final position, check and save lateral and AP images (Figs. 14.6, 14.7a, b, and 14.8)
- For cervical levels: Consider using contralateral oblique view (CLO) where the tip of the needle can be advanced to the ventrolaminar line (VILL) without LOR. At interlaminar line, LOR should be employed. Detailed description provided in cervical epidural chapter

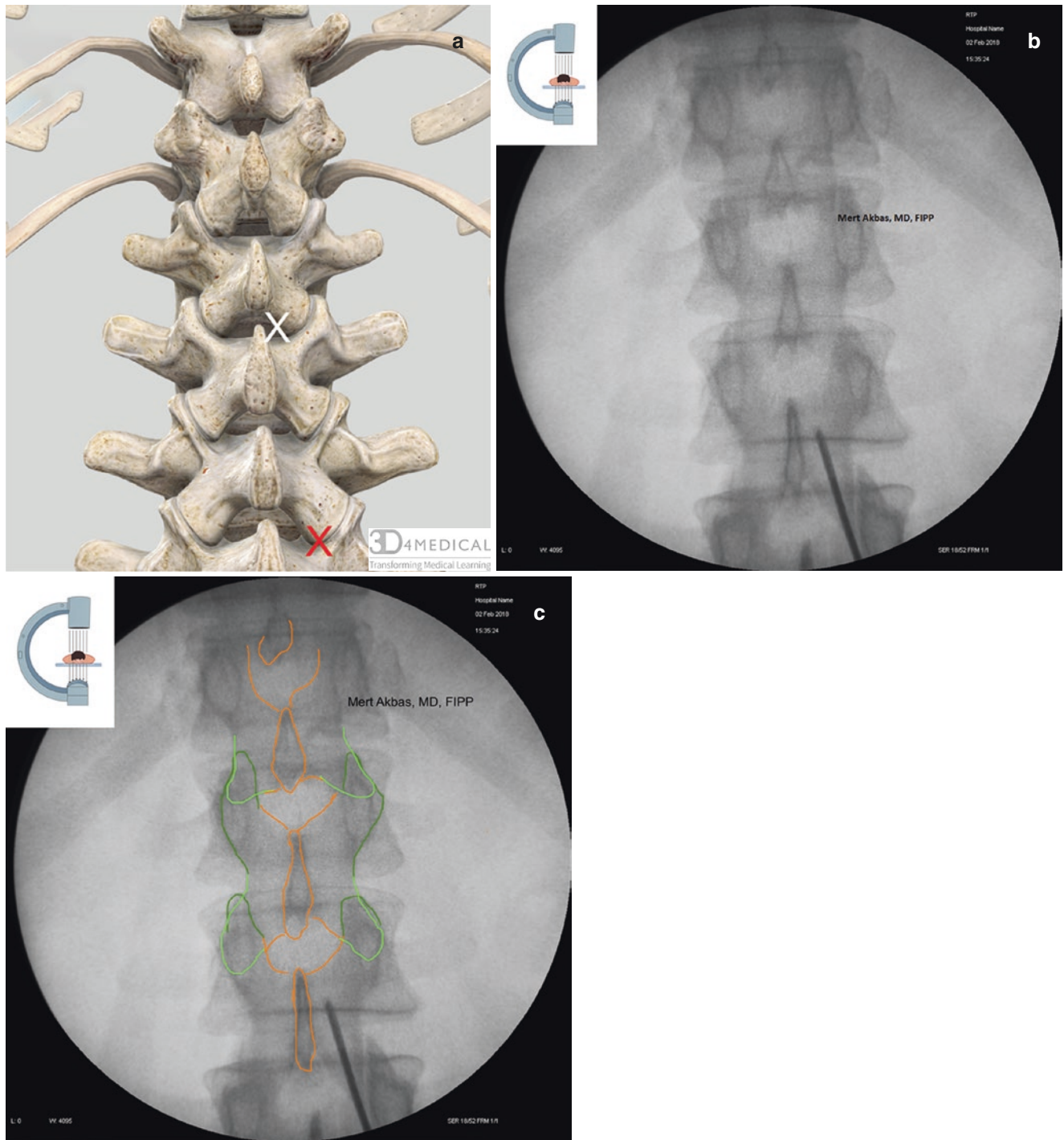


Fig. 14.2 AP image of the thoracolumbar spine, caudad tilt of the C-arm. Skin entry marked with red X, target interlaminar epidural space marked with white X. Needle tip is on the lamina, just below L1-2 interlaminar space. Orange = spinous process and lamina; dark green = superior articular process; light green = inferior articular process. Complete Anatomy image (a), native (b) and edited fluoroscopy image (c)

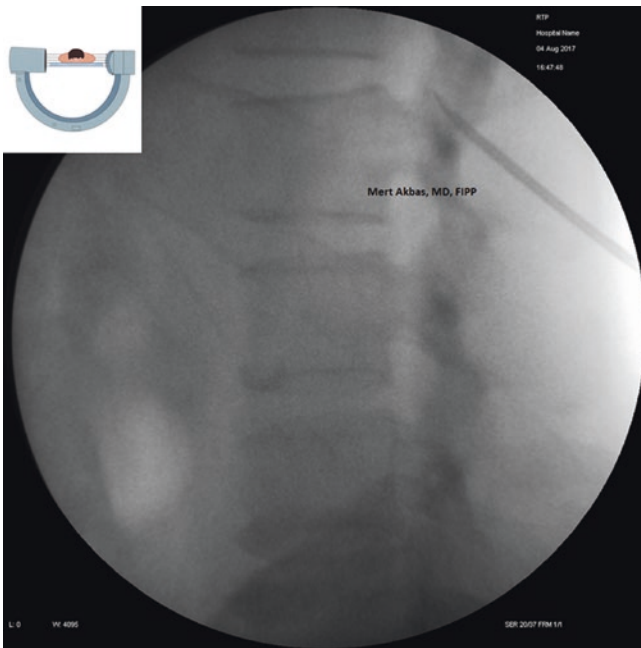


Fig. 14.3 Lateral view of the lumbar spine, needle in L1–2 epidural space after loss of resistance (LOR). Native fluoroscopy image

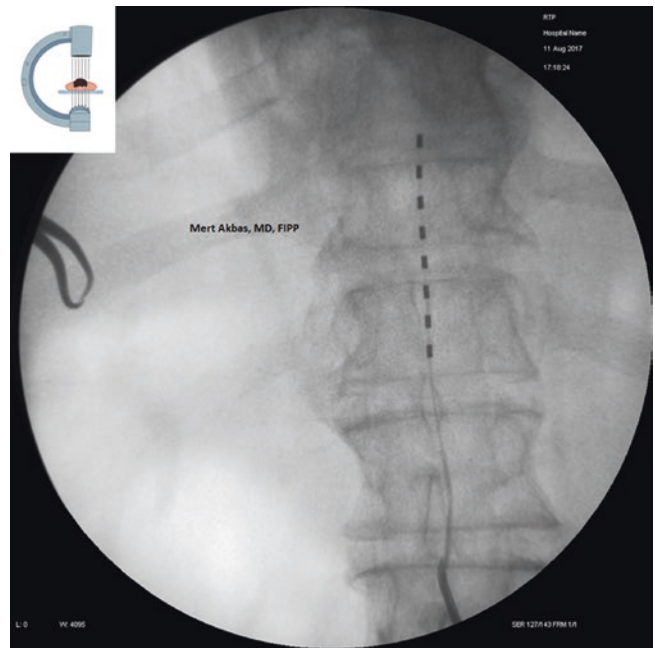


Fig. 14.5 AP image of thoracic spine, SCS lead is at the caudad edge of T10 vertebral body. Native fluoroscopy image

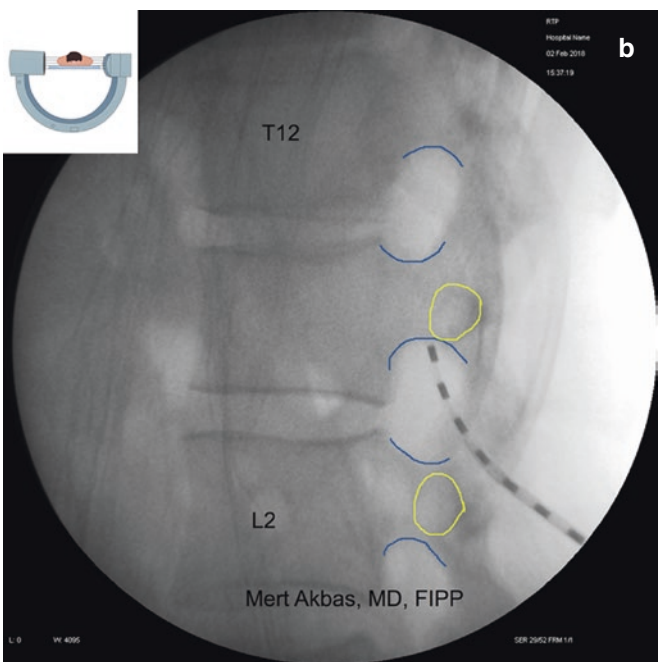


Fig. 14.4 Lateral image of thoracolumbar spine. Needle and lead in the posterior epidural space at L1–2 level. Blue = pedicle; yellow = transverse process. Native (a) and edited (b) fluoroscopy image

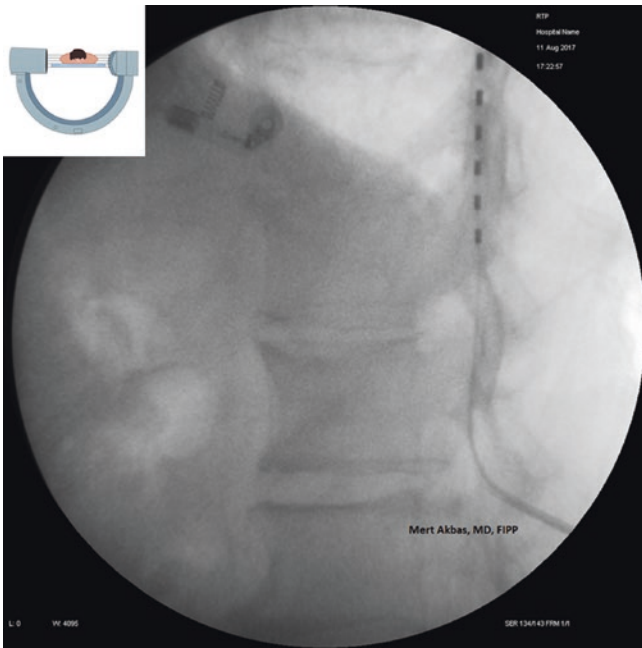


Fig. 14.6 Lateral image of thoracic spine, SCS lead is at the posterior epidural space. Native fluoroscopy image

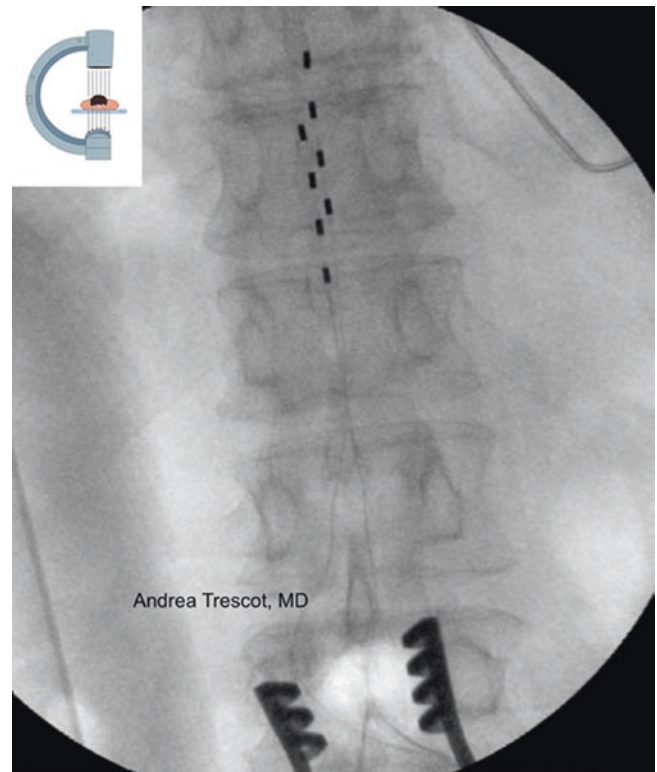


Fig. 14.8 Dual lead placement for better stimulation/coverage. Native fluoroscopy image

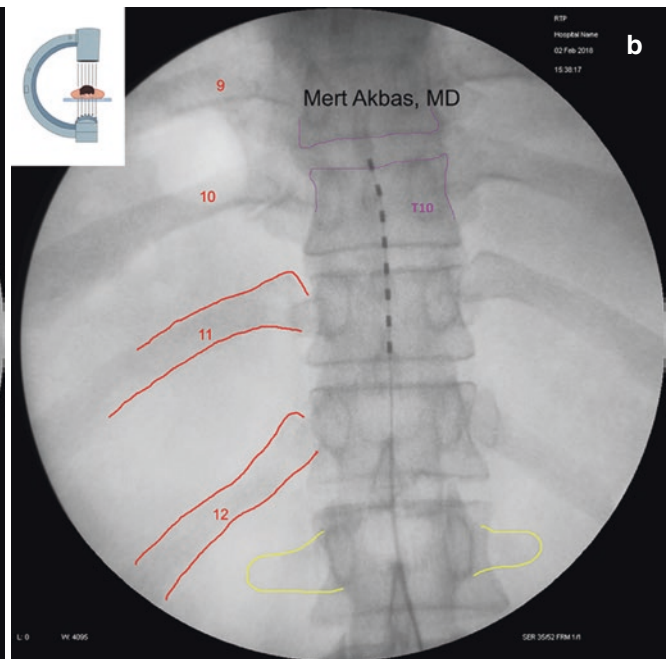


Fig. 14.7 Final lead position, at the cephalad edge of T10 vertebral body. Red = rib; yellow = transverse process. Native (a) and edited (b) fluoroscopy image

Clinical Pearls

- If the needle angle is too acute at epidural entry, it will be very difficult to keep the lead/s in the posterior epidural space
- Always confirm lead position in lateral view especially if patient experiences motor stimulation. This is done to rule out the possibility of anterior migration of the leads
- Repositioning of leads can be performed with a combination of AP and lateral views at regular intervals
- More than one lead may need to be placed for adequate pain area coverage

- Rough needle/catheter manipulation, which may compromise spinal cord
- Obvious signs of lack of understanding thoracic spinal anatomy, for example, placing the lead in the subcutaneous area, posterior to the spinal canal, and believing it is well positioned

Unacceptable, Potentially Harmful Needle Placement on Exam

- Not checking lateral view
- Compromising spinal cord

Unacceptable, But Not Harmful Needle Placement on Exam

- Not reaching the epidural space, but lateral view and LOR technique was carefully utilized to prevent spinal cord damage
- Lead in anterior epidural space
- Abandoned procedure

Evidence

Table 14.1 Level of evidence and recommendations by the Benelux section of the World Institute of Pain

These recommendations are based on both a review of the literature in 2015 by an independent third party (Kleijnen Systematic Reviews LTD) and the previous published guidelines published in Pain Practice. The recent literature, the potential risk for complications, and the grade of invasiveness were considered when deciding to upgrade or downgrade the recommendation.

Indication	Procedure	Recommendation 2009 ¹	Grade 2015 ²	Recommendation 2018 ^{3,4}
Failed back surgery syndrome	Spinal cord stimulation (tonic)	2A+	Moderate	Moderate
Failed back surgery syndrome	Spinal cord stimulation (HF-10)		Not graded	Moderate
Complex regional pain syndrome ⁵	Spinal cord stimulation	2B+	Moderate	Moderate
Painful diabetic polyneuropathy ⁶	Spinal cord stimulation	2C+	Moderate	Moderate
Ischemic pain of the extremities ⁷	Spinal cord stimulation	2B±	High	Moderate
Chronic refractory angina ⁸	Spinal cord stimulation	2B+	Low	Weak

¹Van Boxem K, Cheng J, Patijn J, van Kleef M, Lataster A, Mekhail N, et al. 11. Lumbosacral radicular pain. Pain Pract. 2010;10:339–58

²Kleijnen Systematic Reviews Ltd.: Search and evaluation of the literature. 2015.

³Huygen F, Kallewaard JW, van Tulder M, Van Boxem K, Vissers K, van Kleef M, et al. Evidence-based interventional pain medicine according to clinical diagnoses: update 2018. Pain Pract. 2019;19:664–75

⁴<https://www.anesthesiologie.nl/publicaties/praktische-richtlijnen-anesthesiologische-pijnbestrijding>

⁵van Eijls F, Stanton-Hicks M, Van Zundert J, Faber CG, Lubenow TR, Mekhail N, et al. Evidence-based interventional pain medicine according to clinical diagnoses. 16. Complex regional pain syndrome. Pain Pract. 2011;11:70–87

⁶Pluijms W, Huygen F, Cheng J, Mekhail N, van Kleef M, Van Zundert J, et al. Evidence-based interventional pain medicine according to clinical diagnoses. 18. Painful diabetic polyneuropathy. Pain Pract. 2011;11:191–8

⁷Devulder J, van Suijlekom H, van Dongen R, Diwan S, Mekhail N, van Kleef M, et al. 25. Ischemic pain in the extremities and Raynaud's phenomenon. Pain Pract. 2011;11:483–91

⁸van Kleef M, Staats P, Mekhail N, Huygen F. 24. Chronic refractory angina pectoris. Pain Pract. 2011;11:476–82

Table 14.2 Level of evidence based on the American Society of Interventional Pain Physicians (ASIPP) review of the literature

Spinal cord stimulation ¹	Evidence
Failed back surgery syndrome	Level II
Complex regional pain syndromes	Level II
Diabetic neuropathy	Level IV
Abdominal/pelvic pain	Level IV
Ischemic pain syndrome	Level IV

¹Benyamin RM, Vallejo R, Cedeno DL. Spinal cord stimulation. In: Manchikanti L, Kaye AD, Falco FJE, Hirsch JA, editors. *Essentials of interventional techniques in managing chronic pain*. Springer International Publishing; 2018. p. 659–670.

Levy RM. Anatomic considerations for spinal cord stimulation. *Neuromodulation: Technology at the Neural Interface*. 2014;17:2–11.

Lee RA, van Zundert AAJ, Botha CP, Lataster LMA, van Zundert TCRV, van der Ham WGJM, Wieringa PA. The anatomy of the thoracic spinal canal in different postures. *Reg Anesth Pain Med*. 35(4):364–9.

Sitzman BT, Provenzano DA. Best practices in spinal cord stimulation. *Spine*. 42:S67–71.

Yampolsky C, Hem S, Bendersky D. Dorsal column stimulator applications. *Surg Neurol Int*. 2012;3:275.

This chapter was reviewed by Alan Berkman; Fabricio D. Assis; Andrea M. Trescot; Milan Stojanovic; Peter S. Staats; Agnes R. Stogicza; Andre M. Mansano.

Suggested Reading

Jang H-D, Kim M-S, Chang C-H, Kim S-W, Kim O-L, Kim S-H. Analysis of failed spinal cord stimulation trials in the treatment of intractable chronic pain. *J Korean Neurosurg Soc*. 2008;43(2):85–9.